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Electrical Stocks. AN interesting feature of the recent depression on Wall street was the part played by the Edison stock. While many railroad stocks were tumbling to pieces at a rate that produced general dismay, Edison General stock held its own with but slight signs of a drop until direct attack was made upon the Villard securities, when it dropped more than 20 points, but rebounded like an india rubber ball and recovered all it had lost within about 24 hours. It is a striking sign of public confidence in electrical industries that in a general depression and desperate attacks on allied stocks the result should have been nothing more serious than a momentary drop in value followed by immediate recovery. Considering the fact that a short time ago electrical stocks were looked on with great disfavor in Wall street it is a most encouraging sign of the times to see the marked change in feeling signalized by so great public confidence in the integrity of electrical investments.

English Tramways. AN illustration in the present issue shows what to us may look slightly commonplace, but which to our friends across the water is a striking novelty — an electric car operated by the overhead method. A glance will show that American methods have been followed very closely in the entire arrangement of the system and there is in every detail of the electrical apparatus evidence of American influence. It is a pity that public prejudice against overhead wires is so strong in England that this plan of electric traction is almost impracticable. We in America have learned that the overhead trolley wire is not at all so objectionable as was feared at first, and that at all events it is preferable to waiting for a successful conduit system. In England they seem to have reached a less favorable conclusion, although on account of the climate conduit traction is more difficult than here. We hope that a little practical acquaintance with the merits of the overhead system will convince skeptics that the method is desirable enough to be given a fair trial, even though it does violate the proprieties by putting the supply wire in the most convenient place.

An Aluminium Trolley. WE give elsewhere some account of one of the applications of aluminium to electrical purposes. At the recent Buffalo convention the aluminium trolley was received with great favor by street railway men, and acquitted itself well in some rather severe tests. The great lightness of this trolley compared with those ordinarily in use constitutes an enormous advantage in overcoming the mechanical difficulties of current collecting, and in spite of the greater price the aluminium trolley will find its way into extensive use. Should the next two or three years show the same decrease in cost of production that has been exhibited in the past few years, we shall probably see the new material making its way into use for a large part of the purposes for which brass and iron are now employed. Although the good qualities of aluminium have been grossly exaggerated by over-confident friends, it needs no such extraordinary commendation, for its valuable mechanical qualities speak for themselves, and its real merits are great enough to make an exaggeration unnecessary. No one would willingly employ brass if really cheap aluminium were at hand, and while it may not replace iron or steel to any great extent, it should be remembered that it is as strong as brass and vastly more desirable in every way.

Electricity Meters. ON another page we print an interesting popular account of the various devices which are employed for the purpose of metering electricity to consumers from central stations. As the electric lighting industry comes into sharper and sharper competition with other methods of illumination and comes to be regarded rather as a necessity than as a luxury, the need of metering rather than supplying by contract becomes an urgent one. Although the gas meter is anything but a favorite instrument among householders, there is a certain amount of satisfaction that comes from seeing exactly what is being paid for, and electricity sold by Board of Trade units, or any convenient measure, is likely always to be much more popular than lights furnished by contract per month. Specially is this true of domestic illumination, where a satisfactory contract is very hard to settle upon, since each house is usually wired for a number of lights considerably in excess of the number lighted at any one time. Mr. Shand does not go into details of the mechanism of the various meters employed, but rather sketches out the various forms of apparatus which have been and are applied to the purpose under consideration. It will be seen that meters of all three classes mentioned are to-day in successful use. The Edison, the Shallenberger and the Forbes instruments may be considered typical of the three classes, and each of them has a good reputation for successful work. The meter competition held in Paris may bring to the front improvements upon these that will be of great importance to commercial electricity. For practical use it makes very little difference whether a meter records ampère hours or watt hours, for on any parallel system of distribution it is necessary to keep the pressure very nearly constant in order to secure a service that will be tolerated. Although we have not yet the ideal electricity meter, several of the instruments already in use are at least as accurate as the gas meters that have been adopted, and the gas meter, by the way, in spite of its bad reputation is far from being an inaccurate instrument. The vast majority of gas meters show under test an error of only one or two per cent. This is by no means unsatisfactory in a commercial instrument, but we are convinced that the electricity meter can be made far more exact than this, and consequently will give considerably better satisfaction.

The Electric Railway. THE paper by Mr. T. P. Bailey, read before the Chicago Electric Club, and to be found elsewhere in our columns, is a capital résumé of the present state of the art of electric traction. His statistics are very striking, and ought to be quite sufficient to quiet forever any lingering doubts that may remain in the minds of the skeptical. The proof of the pudding is in the eating, and the experience of the past two or three years has taught that the electric railroad in its present state is a thorough success. Our systems are not by any means perfect to-day, but this should only give the greater confidence in what will be done in the future. Whatever objections may be raised to details of apparatus, the existence of between two and three hundred roads without a single failure is evidence enough that the electric street railway is here to stay and to multiply. Mr. Bailey's statements with regard to grades are most convincing. A long grade of over ten per cent. operated regularly and without serious trouble shows clearly enough that there need be no fear of steep inclines in street railway construction. Such a grade is, of course, highly undesirable, for it requires an enormous amount of power and the strain on the motors is severe, but when necessary it should not be dreaded. In fact, as we pointed out some time since, a motor car should be able to climb a grade of a per cent. numerically equal to its coefficient of adhesion. This would point to even higher figures than have yet been reached in practice. Mr. Bailey's objection to trailers does not seem to us well founded. The kind of accidents to which he refers will not happen if proper precautions are taken, and the trailer is often a very valuable addition to the regular car service. We must take exception, too, to the use of an engine of 20 per cent. greater capacity than the dynamo. An engine rated in the usual way, at a cut-off of one-fourth, will give easily 50 per cent. over its nominal horse power, and, unless it is the intention to overload the dynamo in the most reckless manner, an engine of the extra size mentioned simply needlessly increases running expenses. Only the best and most substantial engines should be used for electric street railway service, and from the standpoint of economy a machine of unusually solid construction and with the best of regulation is vastly better than one of extra size. Cheap and badly regulated engines have no more business in a power station than cheap and poorly constructed dynamos. We hope that we may have more papers on electric traction like this very practical one by Mr. Bailey. They are of great service in putting clearly and effectively what has been done, and in opening the way for a more thorough public appreciation of what is really a public benefit.

Test of a Triple Expansion Engine. ON another page we give a detailed report of a recent test made on the great triple expansion engine which operates the arc light service of the Narragansett Electric Lighting Company, of Providence, R. I. The machine was built by the well-known Allis company, of Milwaukee, that has made so many compound and triple expansion engines for electric service, and was rated at 500 h. p. at about 100 revolutions per minute. The test was a most complete one and was designed to show the actual working efficiency and the exact consumption of steam. Incidentally it furnished some valuable data concerning the power required to run arc lights. With 500 arcs burning the indicated horse power of the engine aggregated 492, including the auxiliary engine used for operating the condensers. It therefore appears that .984 of a horse power was required for a single arc light. The duration of the test was 10 hours, and the average indicated horse power of the triple expansion engine was 515.7. The actual amount of steam required, determined from measurements of the water and not from indicator cards, was 12.94 pounds per indicated horse power per hour. This certainly is a splendid figure for so long a test of an engine in every-day use, and shows very clearly what can be done in the way of economical generation of power by employing the best modern type of triple expansion engine. The steam was somewhat too wet for the best results, which makes the performance all the more remarkable. The growth of electric lighting has reacted on the steam engine in a very marked and at the same time very favorable way. Up to a few years ago nearly all the large work of whatever kind was done by single cylinder Corliss engines of large size. These were admirable machines, but they required on an average not less than twice the amount of steam per horse power hour required in the test we are discussing. The high speed engine was the next development in central station work, and, while somewhat less economical than the machine just mentioned, governed with extraordinary quickness and proved invaluable for central station work where the power was often sub-divided and the smaller cost of installation was an object. To-day, however, when enormous central stations are being operated, something better than a simple engine has become an absolute necessity, and taking a hint from the great success of the triple expansion engine in marine use, the same type of machine is to-day being installed in many stations of considerable size. The economy of fuel is self-evident, and it may be safely said that an engine such as the one tested in Providence will operate its 500 lights on 40 per cent. of the fuel that would be required were it replaced by several high-speed engines of smaller size. Unfortunately, it is not always practicable to use engines of anywhere nearly so great a size, and in smaller machines the advantage of compounding and triple expansion is by no means so marked. Where, however, it is possible to provide regular load for a very large engine, such an one should be installed without hesitation unless in a locality where fuel is very cheap. The high-speed engine has its own province for successful work, but it does not lie in the region of heavy and constant loads. It should be noted that the great engine under consideration is by no means a very low-speed engine, considering its power. Very nearly 100 revolutions per minute were made, and that for a 500 h. p. machine is not slow running. The present test certainly reflects great credit both on the makers of the engine and on the lighting company that was far sighted and enterprising enough to install such a machine in spite of its first great cost. It would have a most wholesome effect on central station practice if every superintendent would hold a consultation with his engineer and figure out the probable saving of fuel that would result from employing engines of the most economical modern type, and it is more than likely that the end of such an investigation would show in a very large number of cases that the extra investment required would be more than justified by the lessened running expenses.

Latest Foreign Electrical News.

(By Cable from our Regular Correspondent.)

London, Nov. 17, 1890.—Professor Ayrton's paper on the "Chemistry of Secondary Cells," read before the Institution of Electrical Engineers last week, produced a very interesting discussion. Experiments since the Edinburgh paper had shown that the current density has a tendency to become too great near the top of the plates. It was suggested that an alteration in shape might remedy this. The deterioration which produces such serious effects in batteries left on open circuit was held to be due to the action upon the negative plates. Dr. Gladstone and Mr. Crumpton took prominent parts in the discussion which followed the reading of the paper.

Trains on the City & South London Railway, which was formally opened by the Prince of Wales a fortnight ago, will begin their regular operation on Nov. 26. The apparatus gives promise of success from the start, and Messrs. Mather & Platt, who installed the electrical part of the plant, have guaranteed that the cost of motive power for the first two years shall not exceed seven cents per train mile. They confidently believe that the net efficiency of the system will amount to not less than 60 per cent. The locomotives employed are, as previously mentioned, of 100 h. p., and cost $7,000 apiece. The test of the line shows that the total loss by leakage over its entire length is less than one ampère, being a very small fraction of one per cent. of its total capacity.

NEW BOOKS.

Manuel Pratique de l'Installation de la Lumière Electrique. By J. P. Anney. Pp. 344, 135 illustrations. Paris: Eugene Lacroix, 1890.

This little treatise is a rather meritorious French example of the practical handbooks which have recently appeared in several languages. On the whole it is well done, and covers the subject of practical electric lighting in a fairly complete way. After a few general rules for installations, it takes up the subject of various motors used, steam engines, gas engines and the like, and then gives a brief but intelligent description of the fundamental types of dynamos, methods of coupling and care. The chapter on accumulators is especially full and more than usually satisfactory. As we have frequently remarked in reviewing other works, this subject of accumulators is one which ought to receive more attention than it does, and a handbook on electric light is not complete without at least a brief practical description of the secondary battery and methods of installation and care. The remainder of the book before us takes up arc lighting with some familiar types of lamp, including the Jablochkoff candle, incandescent lamps, and the various accessories that go to make up electric stations. An appendix gives an abstract of the French laws and police regulations concerning city installations.

Dictionnaire d'Electricite et de Magnetisme. By Julien Le Fevre. Second Part. Electrolyzable-Magnetometre. Pp. 257, 315 illustrations. Paris: J. B. Bailliere et Fils, 1890.

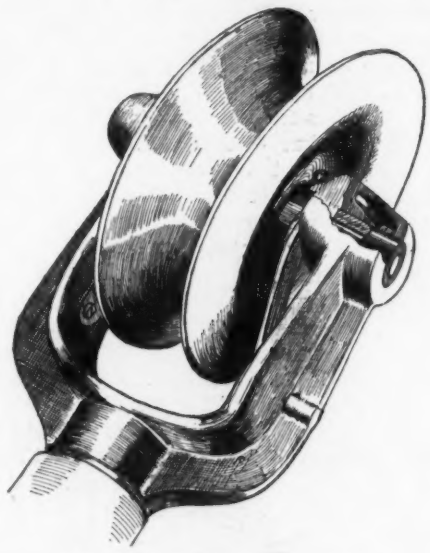
We have already noticed the first part of this electrical dictionary, and the volume now at hand sustains the various merits which we noted formerly. It is emphatically a popular dictionary, especially rich in brief descriptions of an enormous number of kinds of electrical apparatus. Hardly any electrical device or art escapes description and illustration, and for this reason the work is one which is of great convenience for reference as it contains facts very difficult to find elsewhere. The illustrations are for the most part good, although we cannot help regretting that the volume was not printed on better paper, which would allow the numerous figures to show to far greater advantage than at present. Two more parts are to appear shortly, completing the work.

An Aluminium Trolley.

Since the recent advent of comparatively cheap aluminium there have been innumerable attempts to apply it to all sorts of purposes, and the papers have been filled with marvelous tales of the sensational possibilities of the new material. Aluminium is now so well known that there is little excuse for exaggerating its really valuable properties or pretending its applicability to purposes for which it is by no means well suited. In view of this, before entering upon the description of the very useful practical application of the metal illustrated herewith, it is worth while to say something about the actual physical properties of this remarkable and peculiar metal.

As is well known, it never occurs native and its most familiar compound is the very impure aluminium oxide which forms so large a part of clay. Besides this base and common substance corundum with its magnificent species, ruby and sapphire, together with commoner forms, are almost pure aluminium oxide. Crude corundum is perhaps the most available source of aluminium oxide. Of the aluminium manufactured on a commercial scale the usual source is not, however, aluminium oxide, because of the extremely unmanageable character of this material from a chemical standpoint. Two minerals, beauxite, a natural aluminium hydrate, and cryolite, a double fluoride of aluminium and sodium, are far more available as a basis of aluminium reduction on a commercial scale. The latter comes principally from Greenland. The metal itself is now obtained principally by two methods, each of which has a large number of varieties, patented and otherwise. First, the reduction of aluminium salts, usually the chloride or double chloride of aluminium and sodium, by means of metallic sodium. This is the original process of Deville, whose process is still used. More recently it has become available in connection with the beautiful Castna sodium process for the production of aluminium on a large scale in England. Second, the electrolysis of aluminium salts, best accomplished with the material in a molten condition rather than dissolved. The starting point in this method is most frequently the double chloride of aluminium and sodium, or the double fluoride of the same metal occurring in nature as cryolite. This latter process is in substance the one used by the Pittsburgh Reduction Company, whose works are now widely known as the source of cheap aluminium. Besides these methods there is the Cowles process of electric production, best fitted, however, for the manufacture of aluminium alloys rather than the pure metal.

The metal itself is now familiar probably to the majority of our readers, at least in samples. It is a beautiful white metal, with a very slight bluish cast, and when pure does not tarnish in the air, is odorless and has no metallic taste. These statements are not true of most of the commercial aluminium, which generally contains a very perceptible amount of silicon and iron. The most remarkable property, of course, is the very low specific gravity, being for the pure metal very nearly 2.6. The commercial aluminium has more often a specific gravity of 2.7 to 2.8. It is comparatively fusible, melting at a temperature rather higher than that of zinc and lower than that of silver, at a temperature about corresponding to a bright red heat. It is important to notice, however, that in spite of this comparatively low melting point aluminium is one



Lieb's Aluminium Trolley.

of the most difficult of all metals to volatilize. It is almost impossible to cause any volatilization whatever, even at a very intense heat. Nothing short of a deliberate attempt to vaporize it in an electric furnace seems to produce any effect. A piece of aluminium has been exposed in a porcelain tube to the highest heat from a charcoal furnace for ten hours without producing the slightest traces of volatilization, even though for the entire period the interior of the tube was kept very perfectly exhausted by a Sprengel pump.

Regarding the strength of aluminium there has been a vast deal of misunderstanding. In a pure state the metal has an ultimate tensile strength of about 25,000 to 35,000 pounds per square inch, about the same as that of soft copper. It is a favorite habit, however, of the sensational paragrapher to compare aluminium with other metals not by comparing bars of the same size but of the same weight, consequently taking advantage of the very low specific gravity of the metal. This is the cause of many gross misstatements regarding the physical properties of the metal. Weight for weight a bar of aluminium is as strong as steel, but requires nearly three times the cross section to obtain this strength.

With regard to electrical conductivity, different specimens of aluminium vary very widely for the reason that a small impurity, as in the case of copper, may produce an enormous effect on the resistance. The pure metal has probably a little more than twice the specific resistance of copper; that is to say, of two wires of the same length and diameter, the one of aluminium, the other of copper, the resistance of the former would be a little over twice that of the latter. Weight for weight, that is, giving the aluminium wire about three times the cross section of the copper, its resistance would evidently be somewhat less than the copper wire of the same weight. Small proportions of silicon, iron and other impurities decrease the conductivity in a very marked degree.

Of the alloys of aluminium, the most valuable are those with silver and copper, the former on account of its possessing, together with many other desirable properties, almost the lightness of pure aluminium, the latter for their enormous strength, although they are very nearly as heavy as ordinary bronze. Aluminium bronze, like other bronzes, is not a particularly good conductor.

The purest commercial aluminium contains less than a half of one per cent. of silicon and traces of iron. All that is made from natural aluminium salts, such as cryolite, contains far more silicon and iron, the purest being that prepared from artificially purified salts. The percentage of silicon found in the purest specimens varies from one to three or four. The impurer specimens are hard, brittle, lacking the fine color of the pure metal, and are undesirable in many respects. Of the various processes used, the sodium method of reduction at present produces the purest metal, although the electric process will do equally well if pains is taken to use the purest materials. A very good rough test of the purity can be made by trying the metal with the point of a knife. When very pure it shaves up almost as readily as tin, while with two or three per cent. of impurity it can hardly be cut at all. This preface regarding the properties of aluminium seems desirable on account of the somewhat sensational statements that have been too often made regarding a really wonderful metal, and the necessity of understanding the real facts if one wishes intelligently to discuss the application of the metal to various purposes.

The cut given herewith is of a trolley wheel of the standard size and shape used on Sprague roads. Its total weight is only about two pounds, a very great advantage when we consider that this means lighter trolley poles, lighter springs, less danger of breaking down, and far less upward pressure against the wire necessary to produce good contact. Several of these trolleys were exhibited at the Buffalo meeting of the American Street Railway Association last month and scored a great hit. One of them was accidentally subjected to a tremendous short circuit while being tested and stood up under it without the slightest deterioration, thus furnishing a beautiful example of the difficulty with which aluminium is volatilized. Its high conductivity for heat has a tendency to avert melting on such an occasion. This trolley is manufactured and introduced by Mr. Charles Lieb, of this city, and the Buffalo exhibit just referred to was of his make, although exhibited there by the Aluminium Brass and Bronze Company, which makes a very large proportion of the castings.

The construction of this trolley is in some respects peculiar and is well shown in the cut. The wheel is fastened permanently upon a steel axis which revolves in the bearing. These are not metallic, but are formed of a thick lignum-vitæ bushing forced into the aperture furnished in the aluminium trolley holder. About the bushing an oil well, shown where part of the holder is broken away, is provided to keep up perfect lubrication. The marvelous wearing properties of lignum-vitæ are so well known that very little needs to be said to commend them. With an insulating bearing of this sort some special contact arrangement is evidently necessary to lead the current from the wheel to the holder, and this is furnished by a pair of washers, one resting on the axle against the wheel, the other pressed against it by a flat spring, which lead the current to the holder. This contact device is quite sufficient for the purpose and allows a perfection in the bearings and a thorough lubrication which is almost unattainable if an attempt be made to transmit the current through them.

The practical operation of this aluminium trolley is certainly admirable and a large number of them are now going into use on various electric roads. Although the first cost is considerable the wearing properties are so good as to encourage extensive use, and a great advantage is gained by employing so light a trolley. So long as a heavy weight has to be carried at the end of the trolley arm there is necessarily mechanical difficulty in keeping up a good contact without excessive strength of spring and upward pressure against the wire. With the present aluminium trolley, however, a very light pressure is sufficient and light wooden poles with correspondingly easy springs can be employed with entire satisfaction.

Test of a Five Hundred Horse Power Electric Lighting Engine.

Those who have followed the progress of the construction of the very elaborate and finely equipped central station of the Narragansett Electric Lighting Company at Providence, R. I., will be interested in the following results of a recent test of a 500 h. p. triple expansion engine now in service at that station in the operation of arc lights. The general manager of this company is Mr. Marsden J. Perry, the president of the National Electric Light Association, and the detailed description of the plant was presented to the Niagara Falls Convention of that association in August, 1889, by Messrs. Remington and Henthorn.*

The engine in question was built by the E. P. Allis Company, of Milwaukee, Wis., and was guaranteed to develop an indicated horse power with an expenditure of 12.6 pounds of feed water per hour. The test was conducted by Messrs. E. D. Leavitt and John T. Henthorn. The engine was handicapped in the test by moist steam, but the remarkable showing of 12.94 pounds of steam per horse power was made, and, as the result, under the circumstances, was highly satisfactory to the purchasers, the engine was accepted at once.

The engine is of the Reynolds-Corliss type, and its three cylinders are of 14, 25 and 33 inches diameter respectively, the length of the stroke being 48 inches. The cylinders are built with loose heads at each end, the valves, of the

* See The Electrical World, Aug. 17, 1889.

Corliss type, being located in the heads. The cylinders are steam jacketed in the barrels, but not in the heads. The receivers are horizontal and steam jacketed. Steam is taken from the main steam pipe to the jacket of the first receiver. The drain from this goes to the jacket of the second receiver, thence to the high pressure cylinder jacket, thence to the intermediate pressure cylinder jacket. The valve gear is of the Corliss type. The high pressure cut-off is regulated by a centrifugal governor. The intermediate pressure cut-off can be regulated by the same governor or by hand (during the test it was hand regulated), and the low pressure cut-off is regulated by hand. The low pressure valve gear is worked by two eccentrics, one for steam and one for exhaust. There are no means of separating moisture from the steam before entering the engine, nor of removing any water of condensation from the steam after leaving one cylinder and before entering the next one. The engine exhausts to the condenser through a pipe which is intended as an exhaust main for future engines, but for the purpose of this test a temporary exhaust pipe of proper size for this engine alone was led direct to the condenser. The condensing apparatus is entirely independent of the main engine, and consists of a surface condenser, a 16 × 16-inch plunger circulating pump, a 24 × 16-inch single bucket lifting pump without foot valves, and a Corliss type steam cylinder, 12 × 16 inches, working both pumps by crank connections.

At the time of the test the electric street lights were burned to determine the load upon which the engine would come nearest to 500 indicated h. p. Four hundred, 450 and 500 arc lights were thrown on in turn, and two sets of indicator cards were taken at each load. The average of two cards taken with 500 lights showed the main engine developing 475.7 h. p., the auxiliary engine 16.3 h. p., and the aggregate 492 h. p. It was thus found necessary to fix the load at a little over 500 lights in order to keep within the prescribed limit of 25 either side of 500 indicated h. p. At 9:30 P. M., the engine having been run for about two hours, the water was turned into the weigh tank and the counters thrown into gear. Indicator cards were taken at intervals of 20 minutes, the temperature and pressure noted at the same time. The engine was run until 7:30 A. M., when the reading of counters was taken, throttle shut and the water turned off the last tank. The steam pressure was kept fairly steady during the test, except for a short time at midnight, when it was reduced to 110 pounds at the engine through carelessness of the fireman.

The results of the test in full with tabulated records of the observations form a very extended report. The most important facts brought out by the test, however, will be found in the following excellent summary, for which we are indebted to *The Iron Age*:

The test lasted 10 hours, during which the main engine made 59,376 revolutions, maximum 99.93 per minute, minimum 99.10 per minute, and average 99.12 per minute. The condensing engine ran at an average speed of 61.29 revolutions per minute. The maximum steam pressure at the throttle was 128 pounds, the minimum, for a few minutes only, 110 pounds, and the average steam pressure was 125.2 pounds. The average steam pressure in the first receiver was 26.98 pounds, and the average pressure in the second receiver was 1.70 pounds. The vacuum at condenser showed a maximum of 27.7 inches; minimum, 25.8 inches, and average, 26.5 inches. The barometric average was 30.08 inches. The average temperature of injection water was 72 degrees F., of hot well water 109.06 degrees F., and of the engine room 90 degrees F. The indicated horse power of the main engine was maximum 529.7; minimum, 502.2; average, 515.7; of condenser engine, maximum, 17.7; minimum, 14.8; average, 16.41. The aggregate horse power developed was 532.11. The water discharged from the hot well was 63,684 pounds; from the jackets, 10,653 pounds; total from engine, 74,337 pounds. The percentage of total steam used in jackets was 14.33 per cent.; the water entrained in steam, per calorimeter test, 7.39 per cent., amounting to 5,497 pounds, and the net steam used by the engine 68,840 pounds, making 12.94 pounds of steam per indicated horse power per hour.

The experts conclude that the steam per horse power per hour was 0.34 pounds, or 2.7 per cent. in excess of the guarantee, but state that the engine was badly handicapped by moist steam. "The water found to be present in the steam was deducted from the weight of water collected in the tanks in determining the net steam chargeable to the engine, but the presence of this water affects the economic action of the steam with which it is mixed, but to what extent," says Mr. Leavitt, "it is impossible to calculate." It is his opinion that the 7.39 per cent. of water in the steam would make a difference of at least 10 per cent. less duty than would be performed by dry steam, or not less than two and a half per cent. after subtracting the weight of the water itself. Another allowance of indeterminate amount should be made for the steam used by the condensing apparatus engine in excess of what has been used by an engine of the same power, but at the same rate of duty as the main engine, according to the clause in the contract, which was not made known until after the test. It is impossible to say just what allowance should be made for this. On the one hand, this engine is not economical by reason of its unjacketed cylinder and low piston speed, and, on the other hand, it exhausts the steam into the first receiver, so that it does good work in the last two cylinders. Mr. Leavitt's opinion is that an allowance of from one-half to one per cent. would cover the loss of economy due to the small engine.

Spark Lengths at High Voltages.

The German correspondent of the London *Electrician* says that Herr A. Schneller has obtained the following values for spark lengths at high voltages. The readings were taken by means of a Cardew voltmeter connected across the primary terminals of a "step-up" transformer. The spark lengths were fixed beforehand by setting the wires at measured distances apart, and increasing the pressure till a spark took place. The results obtained are shown in the accompanying table:

Pressure.	Sparking distance, millimetres.	Pressure.	Sparking distance, millimetres.
4,300	4	10,700	16
4,700	6	11,500	20
6,750	10	13,100	22
7,800	16	14,200	24

An English Electrical Railway.

Although the English electricians very early entered the field of electric traction, the art has progressed in the British Isles with remarkable slowness. It is not hard to find the cause of this apparent apathy. It appears to rest principally on two things—first, the extraordinary amount of red tape that has to be unwound before permits for any sort of tramway can be obtained; and, secondly, the deep-seated and apparently ineradicable objections to overhead wires. The average Englishman seems to regard a suspended trolley wire with peculiar dislike, and public sentiment is so strong that it is well-nigh impossible to make headway against it.

At the recent Edinburgh Exposition, however, there was exhibited together with a very good example of the telpher line an electric tramway on the Walker-Manville system, operated by means of the overhead wire which is so well known in this country. The motor car, as will be seen from our cut, is not widely different from those which are so familiar to us here. It is of the ordinary gauge with the familiar short wheel base. The method of suspending the trolley wire is almost precisely similar to that now usually adopted in this country. It is perhaps in the trolley that we find the nearest approach to novelty. Both the method of support and the shape of the trolley arm are different from ordinary American practice. The collector, too, is a shoe instead of a wheel, and the nearest American relative to the whole apparatus is the Short trolley. The method of suspending the motor is practically that used here. The field magnets are supported in a cradle of gun metal, which also supports the bearings for the armature and for the countershaft. One end of this cradle terminates in an eye running over a stud supported on a beam carried across the bottom of the car truck. The flange around the eye rests on a strong spring and supports that end of the cradle flexibly. The other end terminates in two plumbers' blocks, which rest directly upon one of the axles of the truck. The armature is geared to the countershaft by cast steel double helical pinions and wheel, and the other end of the countershaft is geared to the car axle in a similar fashion.

It will thus be seen that the method of suspending and gearing is almost precisely that which is in use on every electric railroad in the United States, and has the disadvantages and advantages which are already familiar to us. The exhibition road worked admirably throughout the time it was in operation, and introduced the overhead wire to the British public in a more than usually successful manner. The car illustrated differs in no respect from that used on the Walker-Manville system, which has been vigorously exploited of late.

THE WALKER-MANVILLE ELECTRIC TRAMWAY AT THE EDINBURGH EXHIBITION.

Electricity Meters.

BY ROBERT SHAND.

Before proceeding to consider the subject of this paper it may be interesting to glance briefly at the developments which have secured for electricity meters the wide attention they receive, and which have made them important factors in the success of any general system of electrical distribution.

When the incandescent lamp was first introduced to an expectant public people were quick to recognize its many merits and advantages. and the more consideration they gave the new illuminant, the more apparent became its vast superiority to all other illuminants in use for purposes of interior illumination. It was cleanly and produced comparatively little heat, the atmosphere was not robbed of oxygen and vitiated with combustion products as was the case where gas or oil flames were employed, and it could be used in many places where gas or oil would be unsafe. It was perfectly understood, however, by those interested in the development of the new illuminant that however much it might be admired, however desirable it might appear, its progress into general use would be determined principally by its price. If it cost more than people were accustomed to pay for their light, they would continue the use of the elderly, smoky article, and await the development—that is, the cheapening of the new and cleanly method of lighting. The expense and difficulty attendant on the maintenance of small isolated installations involving the use of steam, gas, or other engines, dynamos, etc., was such as but few people could afford to incur, so that as long as this presented the only means whereby the benefits of the new illuminant could be secured, it must remain a luxury, the desired development could not be effected, and its progress into use must necessarily be extremely slow and unsatisfactory.

Consideration, then, of the practical requirements for the supply of small consumers suggested the construction of central stations where electric energy could be generated on a large scale, and which could be fitted with a wide-spreading system of conductors in such a manner that people so desiring could have stores, houses, etc., within the area of distribution fitted up and electric energy placed at their disposal in a manner analogous to that followed by gas and water companies in their supply systems. The construction of central stations promised cheap distribution, and as at that time cheap production of electric energy by means of dynamo-electric machines was already an accomplished fact, it was assumed quite generally that electrical energy would almost immediately become available to small consumers; but unfortunately many obstacles, then unforeseen, acted to postpone the realization of these sanguine hopes.

Towards the end of the year 1886 it was estimated that the total number of incandescent lamps in use in the United States was only about one-half million, all practically supplied on the two and three-wire, low tension, direct system. Then came the development of the high tension parallel system of distribution employing alternating currents and transformers. Many local companies engaged in arc lighting saw the opportunity afforded them to supply incandescent lamps also, and quickly took their places in the new field of enterprise thus opened. They realized that by using this transformer system many of the obstacles that prevented the growth of incandescent lighting on the low tension direct system, in other than districts closely built, were materially reduced. Numerous new companies were organized that made more or less a specialty of the alternating current system. Their activity reacted on those engaged in the development of direct current supply systems, spurring them to renewed and greater efforts than before, with the result that at the present time a conservative estimate places the number of incandescent lamps in use in the United States at over three millions, of which number probably one-third are supplied on the alternating current system. This development still continues, and its progress is so rapid that one cannot be said to risk much in expressing the belief that we are now on the highway toward the realization of the condition of things eagerly anticipated and hoped for when central station construction was commenced: that is, a distribution of electric energy so cheap and so generally available that all who wish may become consumers and secure its benefits, the one necessary condition being that they agree to pay the exact value of the energy consumed, no more, no less.

This brings us at once to the question, On what depends the value of the electric energy consumed? This question must be answered before we can begin to devise methods of determining the "value received" which it is necessary to know before presenting the consumer with the record of his extravagance—his bill.

The value of the supply depends upon its volume or quantity and the electromotive force or pressure at which it is delivered. The product of the current in ampères by the electromotive force in volts gives the rate of the supply, that is, the power at any time in volt ampères, or watts. The total consumption, therefore, is represented by the product,

volts × ampères × time
or volts × coulombs.

For example: if we suppose two incandescent lamps in use, each taking one ampère of current at 50 volts potential, electric energy is then being converted into heat in the lamps at the rate of 100 watts per second. Assuming the current and the pressure to remain constant for one hour, the energy converted into heat in the lamps during that hour will equal 100 watts for 3,600 seconds, or 360,000 watt seconds or joules. In practice this quantity would probably be expressed at 100 watt hours. It might also be expressed as 265,000 foot pounds or .134 horse power hours. When an ampère hour is spoken of the electromotive force or pressure is disregarded, and an expression adopted which it is sometimes convenient to use, what is really meant being a supply of 3,600 coulombs of quantity of electricity. This supply may be delivered in a second, or in an hour, or any measurable interval of time may be taken in its delivery, but so long as the product of the current strength in ampères by the time during which it was supplied equals 3,600 it may be expressed as an ampère hour.

For the measurement at any particular time of the electrical quantities we are considering; numerous beautiful and accurate instruments are available, but these evidently cannot comply with the conditions for ascertaining the value of a supply, extending it, may be over a month or longer, the reason of this being that they are not furnished with means of constant following and registering its successive progressions. In order to know the value of a consumer's supply with certainty and completeness an instrument must be provided capable of measuring the two factors of the supply, quantity and pressure, and also capable of making a continuous and cumulative record of the supply as it proceeds. An instrument capable of doing this is called a watt hour meter, energy meter or erg meter. When, however, it is considered permissible that the pressure factor be accepted as a constant by which the ampère seconds or coulombs recorded may be multiplied and the product accepted as representing the energy consumed, then the instruments capable of doing this, of recording ampère seconds or coulombs, are called coulomb meters.

In any parallel system of supply the maintenance of constant potential at all points of supply is the characteristic and most important feature, and where it is maintained, coulomb meters may do the work satisfactorily, but where the potential fluctuates between limits not necessarily wide, energy meters would appear to be desirable,

In forming an opinion regarding the relative merits of coulomb and energy meters it must be remembered that what the consumer pays for is energy, and if the potential factor of his supply is allowed to fall the result will probably be a much greater fall in the efficiency of his supply, whether light or power is called for at the point of consumption. It would certainly appear, therefore, that the most scientific instrument, the energy meter, ought also to be the most satisfactory in use, inasmuch as it most nearly measures that which the consumer really pays for. If electrical energy was a material substance, a rarefied combustible for instance, like its would-be rival, gas, it would then be sufficient that the coulomb meter measure its volume, temperature and pressure being constant, in order to know the amount of consumption. Electricity, however, cannot be measured by the cubic foot like gas, and since it cannot be measured directly at all, some of the effects produced in the conductor or in the neighborhood of the conductor must be measured; in other words, it must be made to do work of some kind, and the relation existing between the amount of work done and the electric energy necessary to do it having been determined, the one becomes the measure of the other.

The effects then which electricity is capable of producing are three in number, viz., chemical, magnetic and heating, and these three effects or properties mark three lines along which inventors have labored in the production of electricity meters.

The first of these properties, the chemical, has been extensively applied ever since its laws were discovered by Faraday. When a current of electricity passes through an electrolytic cell containing the salt of a metal in solution, it carries metal with it to the cathode (*i. e.*, the plate by which it leaves the liquid) and deposits it there. The weight of metal thus deposited is proportional to the number of coulombs that have passed through the cell, and, in order to determine the number, it is sufficient that one of the plates be removed from the cell, weighed, and the difference in weight, the amount it has gained or lost, divided by the number representing the weight of metal which an ampère in a second would deposit from the solution contained in the cell.

This method is so beautifully simple, and so easily applied in any direct system of supply, that a superficial view would suggest its immediate adoption. If we study the method closely, however, with the view of applying it to our purpose, we find in the electrolytic cell inherent weaknesses which are apt to become quite important sources of error when the cell is left to itself for any considerable length of time. Non-uniformity in density of solution employed, foreign substances present in the material of the plates, variations of temperature, are some of the causes interfering with the reliability of the method. If we consider also that the consumer is unable to inform himself regarding the progress of his supply by inspecting his meter, and the necessity which exists for taking the meter apart in order to discover it, we will probably concede the possession by the electrolytic cell of many features undesirable in a meter.

The magnetic property of the electric current is apparently the one of which the greatest number of inventors have availed themselves and which they have applied in the construction of meters. Often, when this method is applied the meter takes the form of an electric motor having a revolving armature and fitted with some brake device which absorbs the work of the motor in such a way as to make its rate of movement proportional to the current strength. For example, if the force acting on the armature is proportional to the square of the current, in order that the motor may rotate with twice the velocity when the strength of the current is doubled it is necessary that the square of the rotations measure the brake force against which the motor is doing work; then the square of the number of rotations in a given time is a measure of the square of the electric current. Therefore, the rate of rotation measures the strength of the current and the number of rotations its quantity.

A form of electric motor, in the adaptation of which to use as an electricity meter much thought and labor has been expended by inventors, is that depending for its action on the electromagnetic rotation of mercury. When mercury (or other conductor) is traversed by radial currents (*i. e.*, currents which enter at the centre and leave at the outside, or vice versa) and is at the same time acted upon by a magnetic field, the lines of induction in which act in a direction perpendicular to the surface of the mercury, it will rotate in a direction perpendicular to the lines of force and to the direction of flow of the current. Reversing the field changes the direction of rotation, but if at the same time the direction of flow of the current be changed, the direction of rotation will remain as before. The rotative force is said to vary as the square of the current, and the speed as the square root of rotative force. Liquid friction, therefore, in this case supplies the necessary controlling force. We see, therefore, that such a meter should be applicable to both systems of supply. With one notable exception, however (which will be mentioned later), inventors would seem to have met but scant measure of success in the adaptation of this form of motor meter.

In another application the meter takes the form of a machine driven by a constant force and controlled by a force which is also constant so long as no current passes through the conductor. Immediately when the current passes, however, the controlling force is modified and the velocity of the machine accelerated by a quantity determined by and proportional to the rate of consumption. The acceleration thus becomes a measure of the consumption.

The heating effect of the electric current has received much attention and many applications has been made of it to the work of electricity meterage since alternating current supply systems became prominent. When a current of electricity passes through a conductor resistance is encountered and heat is generated, as shown by Joule, at a rate represented by the resistance multiplied by the square of the current. The heating effect being practically the same with alternating and with direct currents, its application seemed to promise a meter equally applicable in both systems of supply, which would approach the electrolytic method in its simplicity and share at least one important advantage of the magnetic method, inasmuch as it might readily be made to register on dials. Numerous novel and beautiful applications of the heating property of an electric current have been made by Prof. Elihu Thomson to meters, giving their indications by the expansion of gases, by the evaporation, under special conditions, of various liquids, and in other ways.

The ordinary compound bar formed from two strips of material, generally metals possessing different co-efficients of expansion and firmly attached to each other throughout their length, may also, in certain combinations, be applied to metering purposes. If one end of such a bar be fixed and the other end left free to move under the influence of heat, the free end will be deflected through a distance which will be greater or less according as the heat producing the deflection is greater or less. If an inking stylus be attached to the free end of such a bar, and a cylinder or circular dial carrying a properly lined chart revolved at a constant speed in such relation to the bar that the stylus bears lightly against the surface of the chart, heat developed in the bar will cause it to be deflected and the stylus will trace a line on the chart at a greater or less distance from the zero point, according as the flow of current heating the bar is greater or less. It is apparent, however, that an ordinary compound bar being a simple temperature-measuring device will have motions of its own, independent of the current effect, produced by variations of temperature in the surrounding atmosphere. Errors due to this cause must be avoided. Profs. Geyer and Bristol, in a meter invented by them and constructed on the above plan, avoid this source of error by substituting for the common bar its equivalent made from two pieces of the same material, to one of which is given a radiating surface very much greater than that possessed by the other one. These pieces are firmly secured together, but insulated from each other throughout the greater portion of their length, and are traversed in series by the current which it is desired to measure.

The meter of Prof. E. W. Rice is an integrating or recording meter, and in its construction the arrangement of

the compound bars at once eliminates all danger of errors arising from changes of external temperature. In its arrangement two bars are used, which are secured a short distance apart, their free ends being yoked together. The construction of the bars is such that a very slight development of heat is sufficient to effect a considerable displacement of the free ends. Heat is developed in the bars alternately, one only being in the circuit at any time. A slow vibration of the bars results, and within certain limits the rate of vibration can be made to measure to a close approximation the rate of flow of current, which is registered on a common counter in the usual manner.

Another method is that applied by Prof. Forbes. The current to be measured is passed through a conductor placed under a glass or metal cover. When the conductor becomes heated, connection currents circulate in the air in which the conductor is immersed, and these currents are made to expend a portion of their energy in driving a mechanism which effects the registry.

We will now briefly consider a few of the meters which have met with more or less extensive application in practical work. A meter which has been much noticed of late is that known as the Aron meter. This meter is a development of the clock erg meter proposed by Profs. Ayrton and Perry many years ago. Its operation depends on the fact, that, within certain limits, the rate of vibration of a pendulum increases with the square roots of the the forces attracting it. In one form of this instrument a permanent steel magnet forms the pendulum bob, and immediately underneath, secured to the base of the instrument, is placed a coil of wire through which the whole of the current to be measured is passed. In the meter case are placed two clock movements; one drives an ordinary pendulum the other drives the pendulum carrying the magnet; the acceleration of the latter due to increase of the attracting force acting on the magnet when current is passing in the coil is, by means of differential gearing connecting the two clock movements, indicated upon dials which are read by the aid of a constant experimentally determined for each instrument. This arrangement constitutes a coulomb meter.

The arrangement originally proposed by Profs. Ayrton and Perry (who seem quite early to have recognized the importance of the meter question) was that of an energy meter, the pendulum bob being a fine wire coil of high resistance connected in shunt across the installation. The latest form of the Aron meter, one which is applicable to the meterage of both alternating and direct systems of supply, is constructed according to their method, the bob being a coil of thin wire attached to the end of the pendulum rod and encircled by the horizontally placed current coil. An interesting feature of this meter is the differential gearing. Two wheels each about one and a quarter inches in diameter, and having two sets of teeth, being at once spur wheels and crown wheels, are placed about half an inch apart and driven in opposite directions on the same axis, one by each of the clocks. The cylindrical (or crown) gears are placed opposite each other, and a small planet wheel, free at the same time to turn on its own axis and to roll around that of the cylindrical gears, is arranged between the latter, engaging both. Evidently if the velocity of the two wheels is equal and opposite, the planet wheel will simply be turned on its own centre, but if one of thew heels be driven at a greater velocity than the other, then the planet wheel will suffer a displacement, and will be carried round bodily in the direction and rotation of the wheel having the greater velocity, and this displacement being recorded indicates the consumption. When carefully placed in position, and delicately adjusted, this meter operates satisfactorily, and is sufficiently accurate. It is, however, large, and as yet costly, and it also requires that the clock springs be wound up about once a month.

The meter constructed by Prof. Forbes and introduced by him some two years ago is a beautiful instrument, sufficiently economical and capable of metering alternating and direct currents with equal accuracy. It would, therefore, seem to possess the qualities necessary to secure it a wide application in practical work. It does not appear, however, to have been applied to any extent in the United States. This meter depends for its action on the air currents created by the heat developed in a spirally arranged conductor attached to the base of the instrument; the resistance is said to be about one-hundredth of an ohm. Pivoted above this conductor is a light paper cone having a small pinion attached at the apex and a ring of thin mica at the base. Around the periphery of this ring are fixed eight small cylinders of pith, each carrying a light mica vane inclined at an angle of about 45 degrees to the mica ring. Inside the pinion at the top is a ruby jewel, which rests on a needle point supported upon and rising from the base of the instrument. When current passes through the conductor the convection currents rising impinge on the vanes and cause the cone to revolve (at a rate which Prof. Forbes succeeded in making almost exactly proportional to the current passing through the conductor) and to drive the counter which registers the number of revolutions. The revolving part of this meter is exceedingly light, and when the recording train is carefully constructed, the friction, it is claimed, is relatively small, even when the current is only one-twentieth of the meter's rated capacity. This instrument is, of course, a quantity or coulomb meter.

The meter of Mr. Shallenberger is essentially an alternating current quantity or coulomb meter. The construction of the meter is about as follows:

A coil of copper wire of oblong shape placed horizontally and traversed by the whole of the current to be measured constitutes what may be called a primary or inducing circuit. Secured in the interior of this coil are a number of bare copper punchings, which together form a closed secondary circuit, and become the seat of induced currents. The planes of the primary and secondary coils cross each other at an angle of about 45 degrees. Inside the secondary closed coil, and closely embraced by it, is a thin ring of soft iron secured on a light steel shaft, which is pivoted vertically and free to rotate. The pulses of current, alternating in direction and flowing through the outer coil to the lamps, induce secondary currents in the closed conductor, and also at the same time polarize the iron ring. Assuming these poles to be formed along the magnetic axis of the coil creating them, they will immediately be attracted toward the field of the closed secondary circuit, situated at an angular distance of about 45 degrees. Thus the pivoted iron being free to rotate, a motive force is created which is within the range of the instrument approximately proportional to the square of the current. The controlling force in this meter is afforded by air friction, which opposes the motion of a four winged fan, secured to the shaft carrying the iron ring. It is evident the indications of this meter must be affected by barometric and temperature changes, and also, to some small degree, by changes in the rate of alternations. The former effect would probably be specially noticeable if meters calibrated at sea level were used at varying heights above sea level. These meters are made of 20 and 40 ampère capacity, and a large number are said to be in use.

The meter of Mr. Ferranti, though almost unknown in the United States, is said to be extensively employed in England in connection with the supply system of that inventor. This is a kind of motor meter having a magnetic circuit which suggests that of Dr. Hopkinson's Manchester dynamo, the top pole piece, however, being prolonged downward and wound with a few turns of copper conductor, around which the current is led to the mercury, which it traverses radially. The mercury being placed in a gap in the magnetic circuit and crossed by lines of force, rotates, carrying a small paddle around with it. A small pinion fixed on a slender shaft rising from the paddle drives a carefully jeweled train of wheel work which registers the revolutions. Long range is one of the points aimed at in this meter and the iron used in its construction (which is laminated) being necessarily but slightly magnetized, the driving force developed by small currents is feeble, thus making the internal friction of the machine relatively important.

Prof. Elihu Thomson early realized the importance assumed by internal friction in meters dynamical in their action and devised a method by which errors due to it could be made vanishingly small without making extreme delicacy of construction necessary; this he accomplished by supplying to the meter subsidiary energy by means of a shunt or special winding, for instance, sufficient to create a force equal to that opposed by friction and inertia. Since that time the method has been applied by others. Mr. Ferranti winds on his meter magnet a high resistance shunt coil in addition to the conductor carrying the current measured. Arranged in this way a 50-ampère meter is said to start with less than one ampère, a range and a delicacy which are certainly remarkable in an instrument of its class.

An exceedingly interesting application of the electrolytic method to the metering of alternating currents has been made by the English firm of Lowrie, Hall & Co. In applying their method the inventors include in the secondary circuit of the transformer an electrolytic cell containing a saturated solution of copper sulphate in distilled water. The copper plates employed in the cell expose a surface of four square inches per ampère with maximum load. In the same box with the deposition cell is placed an accumulator cell, and the entire current supplied to the lamps is passed through these two cells in series. The effect of this arrangement is to introduce an electromotive force of constant direction into the circuit which adds itself to the alternating electromotive force during the half period when it is in the same direction, and subtracts itself during the half period when it is in the opposite direction. If, for instance, the alternating electromotive force equals 100 volts, and the constant electromotive force of the accumulator cell is two volts, then in the one direction there is acting an electromotive force of 102 volts, and in the other direction, an electromotive force of 98 volts. The volume of current, therefore, flowing in one direction during a half period is greater than that flowing during the other half period by a quantity equal to four volts divided by a resistance which is determined by the number of lamps in circuit. This quantity of current is available, therefore, to make a record in an electrolytic cell. This system does not suggest itself as a very practical one, but is, however, exceedingly interesting from the fact of its being the only application of the electrolytic method to the commercial meterage of alternating currents.

In this article it has merely been attempted to describe a few types of meter in common use. A very large number, however, have been invented and from time to time introduced. Reference, however, to the work of each inventor is more than can be attempted in any single article on the subject. And still the work goes on, no existing electricity meter satisfying all requirements so fully as to render its use completely satisfactory.

The Buffalo Electrical Society.

This organization is a branch of Buffalo "Society of Natural Sciences," and is in a flourishing condition. Meetings are held on the first and third Monday evenings of each month, at the rooms of the society in the Buffalo Library building. The programme as arranged for the season of 1890-91 is as follows:

Nov. 17, "Conception, Development and Future of the Storage Battery," Wm. H. McDonald; Dec. 1, "Electro-Therapeutics," Dr. Roswell Park; Dec. 15, "Advance of Electric Traction," Frank Kitton; Jan 5, "Phenomena of Earth Currents," William Finn; Jan. 19, "The Chemistry of Electrolysis," Wm. H. Dopp; Feb. 2, "Informal Talk on Telegraphic Subjects," A. C. Terry; Feb. 16, "Electricity in the Household," F. P. Jones; March 2, "Effects of Electric Light on the Eye," Dr. Lucien Howe; March 16, "The Telephone," M. Beecher Marvin; April 2, "Present Status of the Transmission of Electrical Energy by Water Power," Madison Buell; April 16, "Arc and Incandescent Electric Lighting," J. P. Chapin; May 6, "On the Efficiency of Alternating Current Motors," Edward E. Wilson; May 20, "Electrical Measurement," Cuyler C. Smith; June 3, "Observations on the Effects of Static and Dynamic Induction," Astley C. Terry.

The officers of the society are: W. H. McDonald, president; F. P. Jones, vice-president; Astley C. Terry, secretary; Samuel Stewart, treasurer; and Wm. C. Lewin, librarian.

The Telephone Suggested in 1854.

In the *Didaskalia*, a weekly paper published at Frankfort-on-Main, dated Sept. 28, 1854, was printed the following article on "Electrical Telephony." In the second edition of Comte Theodore du Moncel's "Exposé des Applications de l'Electricite," published in Paris in 1857, Vol. III., p. 110, is given a description of a telephone by Charles Bourseul, but du Moncel gives no reference to the original paper describing the invention. The article in the *Didaskalia* is as follows:

The number of miracles with which electricity has astonished us lately is said to have been increased by one which would not only cause a revolution in electrical telegraphy, but would add considerably to its utility. The invention in question is nothing less than the electrical transmission of the "spoken word." The idea was conceived by an educated and modest young man named Charles Bourseul (now living in Paris), who was a private in the African army in 1848, where he brought himself under the notice of the Governor-General by a course of mathematical lectures which he gave to his comrades in the garrison of Algiers. Possibly Bourseul's scheme, of the practicability of which he is perfectly convinced, may be one of those which learned men will afterwards declare very simple, and which, if troubled about, would have been brought out much sooner. The principle of electro-telegraphy, as is well known, is the following: an electric current passing through a metal wire surrounding a piece of soft iron, transforms the latter into a magnet. The magnetic properties of the iron vanish when the electric current is discontinued. This magnet, called the electromagnet, can, therefore, alternately attract or repel a movable plate which by its forward and backward movements produces the conventional signals used in telegraphy. It is further known that all sounds are transmitted to the ear through the air vibrating; and that, therefore, sounds are virtually vibrations of the air, and that the infinite variety of sounds is solely dependent on the rapidity and strength of these vibrations. If it were possible to construct a metal plate, sufficiently sensitive and flexible to admit of the reproduction of the vibration of sounds (like the air), and if this plate could be connected with an electric current in such a manner as to alternately interrupt and continue it according to the vibrations of the air to which it would be exposed, it would be equally possible to electrically affect a similar metal plate so as to repeat exactly and simultaneously the vibrations of the first plate. This would create the impression as if the speaker had spoken in immediate vicinity of the second plate, or, if put differently, the ear would be affected in a similar way as if it had received the sounds through the first metal plate. Electrical telegraphy, which was once academically declared to be almost an absurdity, is now almost universally established; and if we investigate this new idea of the young scientist on the principles of physics, we find that not only no objection could be raised against the soundness of his theory, but that its practicability is more probable than that of electrical telegraphy was only a short time ago. If the theory should prove a success, electrical telegraphy will attain a position of general usefulness. No special knowledge or apparatus will be required except a galvanic battery, two suspended plates, and a metal wire. Without any other preparation one person will have to speak into one of the plates, while the other person places the second plate close to his ear, thus enabling them to converse as if in private. The youth-

ful inventor is confident of the success of his invention, and challenges scientists to prove the impracticability of his theory on scientific grounds. In the meantime the invention fully deserves the attention which will, no doubt, be bestowed on it.

Hill's New Arc Light Cut-Out.

It is the experience of all electrical engineers that there is a constantly increasing demand among users of electric lights and power for more perfect and more substantial apparatus; that the construction of dynamos, motors, line work and every appliance pertaining thereto, shall be made in the most reliable manner and of simplest construction. Responding to this demand, manufacturers are supplying many high grade and efficient goods.

Prominent among those who have realized how very important it is for the continued growth and expansion of the electrical business that ingenuity, skill, and first-class material are among the chief requirements, is Mr. Warren S. Hill, 133 Oliver street, Boston, whose many useful inventions are valued and used for their effciency and substantial make. The cut-out switch, shown in the

Hill's Arc Light Cut-Out.

accompanying illustration, has been designed to be used on arc light circuits, for cutting off or on any number of lamps without disturbing other lamps on the same circuit.

The mechanism consists of three pairs of contacts, two spring actuated levers pivoted at a common centre, and carrying insulated connections that make the circuit between the contacts. The levers are operated by a cam, the shaft of which projects through the iron case and is provided with a handle as shown in the cut.

All the parts are mounted on a slate base and are protected from the action of the weather by the iron case in which the whole apparatus is enclosed. The case itself has a glass front through which can plainly be seen in bold letters the words "on" or "off" according as the circuit is closed or open.

Another form of the same device is also manufactured for arc circuits. The cut-out is made with the same form of contacts as Hill's double pole switch. It is a combination of two of the double pole switch levers pivoted to one common centre, and operated by a handle so arranged that one contact cannot possibly be opened until the other has been made and securely locked in its proper position.

The Electric Light for Divers.

Mr. Applegarth, says the London *Electrical Engineer*, recently exhibited at the offices of *Electrical Plant* in London some improvements in diving dresses which have been carried out by M. Denayrouze. In the new dress there are but three pieces—helmet, collarette and body; and the helmet is fitted to the collarette by a screw-spring adjustment, thus doing away with all loose pieces in the shape of nuts. The dress has been adopted in the French navy. The helmet is also fitted with an incandescent lamp, inclined forward at an angle of about 30 degrees, and fitted with protector and mirror. On Monday the lamp was fed from an accumulator. If it is proposed, as we believe it is, to have the battery in a boat, and that the diver shall drag the leads about with him, we do not think the plan will work well, especially where the searching of wrecks is in question. To our mind, says our contemporary, it would be more practical to equip the man with a water-tight knapsack, fitted with cells, somewhat after the fashion that Siemens adopted for the ballet girls at the Savoy Theatre when "Iolanthe" was being played. The idea of affixing an incandescent lamp to a diver's helmet is credited to M. Marcillhazy, of Paris. Mr. Applegarth also showed and described the Denayrouze respirator, in combination with the upper half of a diver's dress and helmet, fitted with an electric lamp for use in ascertaining the seat of a fire in a ship's hold, when as yet there was more smoke than fire.

A Novel Trolley Base.

Since the electric railroad has come into general use the ingenuity of inventors has been sorely taxed to produce a trolley base having the combination of qualities most desirable for railway service, attempts in this direction

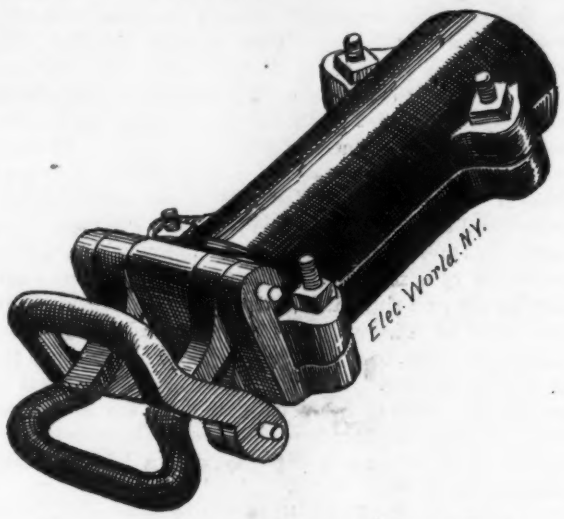


Fig. 1.—Link and Socket for Trolley Pole.

having been almost as numerous as the new cut-outs. But the difficulties to be met are so many that comparatively few of the many devices have met any marked success. Flexibility in all directions without readjustment, combined with springs powerful enough to give the proper contact against the trolley wire, is a hard condition to fulfill. One of the most successful recent efforts in this direction is that illustrated herewith. It is, like many other street car devices, due to the ingenuity of Mr. Charles Lieb, 23 Vandewater street, New York.

Fig. 1 shows the peculiar link that supports the socket for the trolley pole; Fig. 2, the general arrangement of springs. As will be seen from a glance at the latter cut, the spiral spring which has been almost universal in trolley work has been abandoned in this form of support, and its place has been taken by two flat steel springs like carriage springs. These are supported on a single casting which is bolted to the roof of the car. The socket for the trolley pole is provided at its lower end with a pair of wide links hinged upon each other; to each of these are attached two chains, one running to either spring. As a result, the socket is supported by four

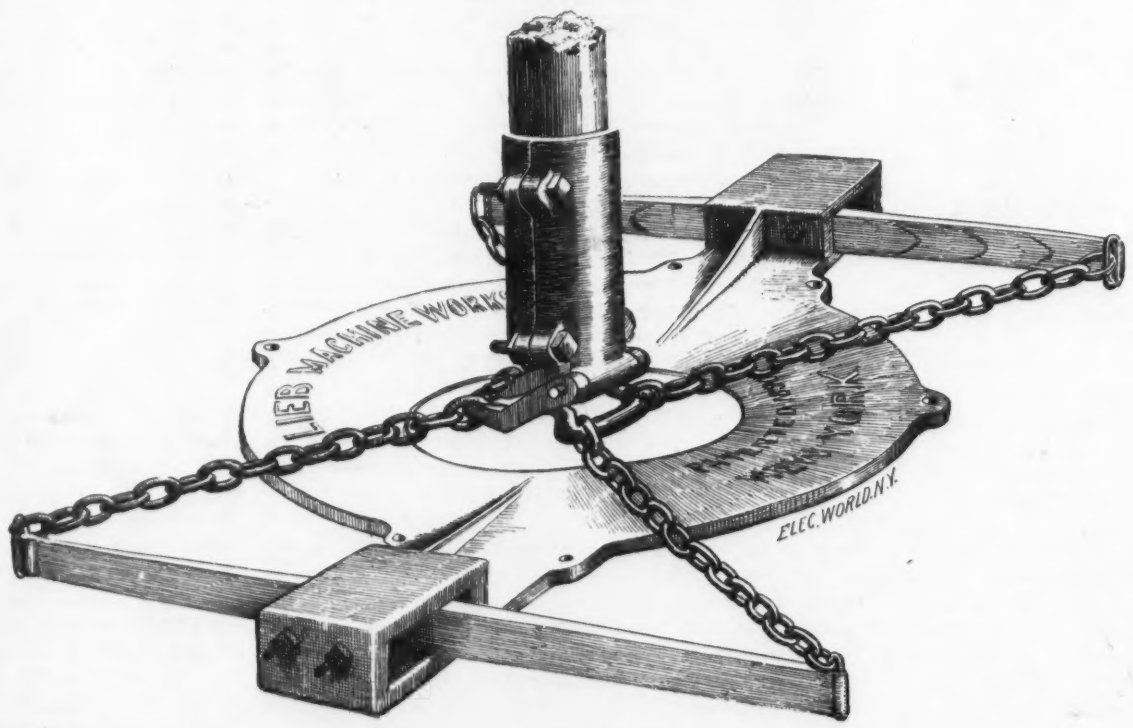


FIG. 2.—LIEB'S TROLLEY BASE.

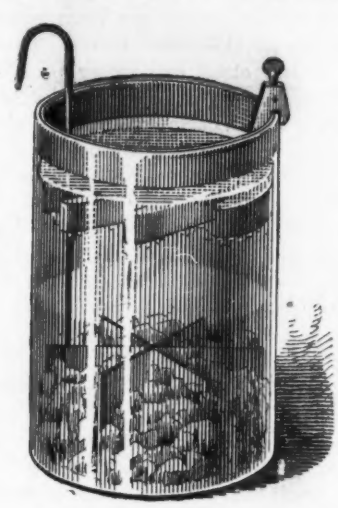
tense chains, and the movement in any direction whatever tends to shorten these, and, consequently, gives the necessary upward pressure against the trolley arm. A special peculiarity of this form of spring is that when the pole is depressed below a certain point the position of the links is such that it can be swung down parallel to the car roof with but little additional pressure, the maximum upward thrust being somewhere midway of the arc through which the pole can swing. This is a great convenience in passing under low bridges, and in laying up the car for the night, for this can be readily done without unshipping the pole.

The whole arrangement is singularly simple and strong and possesses great flexibility in suiting the various positions that must be taken by a trolley pole from time to time. It is really a very meritorious addition to the list of new trolley holders and appears to be meeting the success that its excellent qualities deserve. It is usually fitted by Mr. Lieb with a wooden trolley pole supporting one of the aluminium trolleys, described elsewhere in this issue. Together this arrangement forms a most admirable means of taking the current from the trolley wire, and it is singularly compact and light.

The base only rises four and one-half inches above the roof of the car and is made as light as consistent with the necessary strength, while the use of flat springs obviates the many annoyances that come from the breaking of spiral ones.

The Delany Battery Strip.

Those who have had experience with the creeping of the salts in gravity, Leclanché, and other cells will appreciate the value of the Delany patent battery strip, illustrated



Delany's Battery Strip.

herewith, which is designed to prevent all trouble from this source in the use of primary batteries. Mr. Delany referred to this device last year in his paper read before the American Institute of Electrical Engineers, Nov. 19, 1889.*

The strip is made of rubber cloth. One side is covered with a sticky compound. When properly applied it will never come off of the jar. It offers a mechanical obstruction to the creeping salt, which masses underneath the strip, and is re-dissolved in the battery fluid each time that water is added to the solution to make up for evaporation. All waste and exhaustion of batteries by local action is prevented, and shelves are kept perfectly clean and dry.

Before putting this strip on the market a thorough test covering one year has been made. At the end of that time both gravity and Leclanché jars were found to be as clean and dry on the outside as when first set up.

Steel Versus Iron for Electric Street Car Wheels.

It is to be observed that while most everything else pertaining to motive power, especially for electric service, was discussed at the meeting of street railway officials at the Buffalo convention, very little, if anything, was said about wheels. This is a matter of considerable importance and is frequently discussed among steam railroad officials. At a late meeting of the New England Railroad Club the matter of steel tires, their proper care when in service, and suitable machinery for turning and trueing them up, as well as the application and effect of the brake shoe upon the tires, was discussed in an interesting and most practical manner. Safety and economy in service are the two prominent features in steam railroading. To a considerable extent steel is superseding iron for the wheels where speed and great safety is involved, and would be adopted to a much larger extent if it were not for the great additional expense, some five to eight times, according to the wheel.

When we come to consider the street railways we find other considerations more prominent, for no doubt the wear and tear on a wheel is more severe. The roadbed is so constructed that the track is very near the surface of the ground, or, what is worse still, the paving of the roadbed,

* See The Electrical World, Nov. 30, 1889.

The track is not as carefully and uniformly laid, and the roadbed may be affected by the action of frost in cold weather and become very uneven. The rails are not as frequently renewed, and in many instances are allowed to become very much worn. Wheel makers often complain of this, and say much greater service might be had from the wheels if the track was in better condition. Then again—and this is a serious question—much complaint is made of the application and use of the brake shoe. Some use a chilled iron, which is severe for a wheel. The hanging of the brake shoe is defective, and the shoe is liable to bear on the flange of the wheel, when it should never be allowed to touch the flange. It will grind and cut away the flange and greatly affect the life of the wheel.

We notice frequent allusion to the introduction of new wheels, especially in steel or steel tired, for street railway service, and numerous claims are being advanced why steel is better adapted for wheels, in the electric service especially. These should be taken up and carefully and intelligently discussed, not only for the good of the public, but more especially with a view to taking advantage of every improvement and gain in power or service. There is no doubt that steel can be made stronger than iron, and will, if properly cared for, last longer. It seems reasonable that the claim advanced that at the point where the steel wheel comes in contact with the steel rail closer adhesion is had, and, of course, better traction is the result. If this is true it is a matter of great interest and importance to all interested in street railroads.

Success of Electric Traction in Boston.

The annual report of the directors of the West End Street Railway, for the year ended Sept. 30, was presented to the stockholders at their meeting last week. In the review of the year's business, it is said that experience has shown that wherever the electric lines have been installed travel has enormously increased. The company has during the year contracted for 150 long box cars, seating 34 people, to take the place of the electric cars now in use seating 22 passengers each. These are all to be delivered before Feb. 1, 1891. A part of the statement of permanent investments is as follows: Construction, $5,309,173.09; real estate, $5,796,547.53; general equipment, $423,160.52; 6,927 horses, $928,218; 1,694 cars, $1,310,977.42; 337 electric cars, $1,192,048.22; electric line equipment, $463,643.34; power station equipment, $293,938.56.

The report shows a total of 256.786 miles of track operated, of which 239.45 is owned; 65.46 miles are completely and 27.6 miles are partially equipped with the electric overhead system. There are 74.19 miles of feeder lines; 17,665,365 miles were run during the year; 114,853,081 passengers were carried and 2,344,570 round trips were run; increase 139,211, or 6.31 per cent. Average receipts per passenger were 4.944 cents, a decrease of .017 of a cent; average expense per passenger, including taxes and interest account, 4.103 cents.

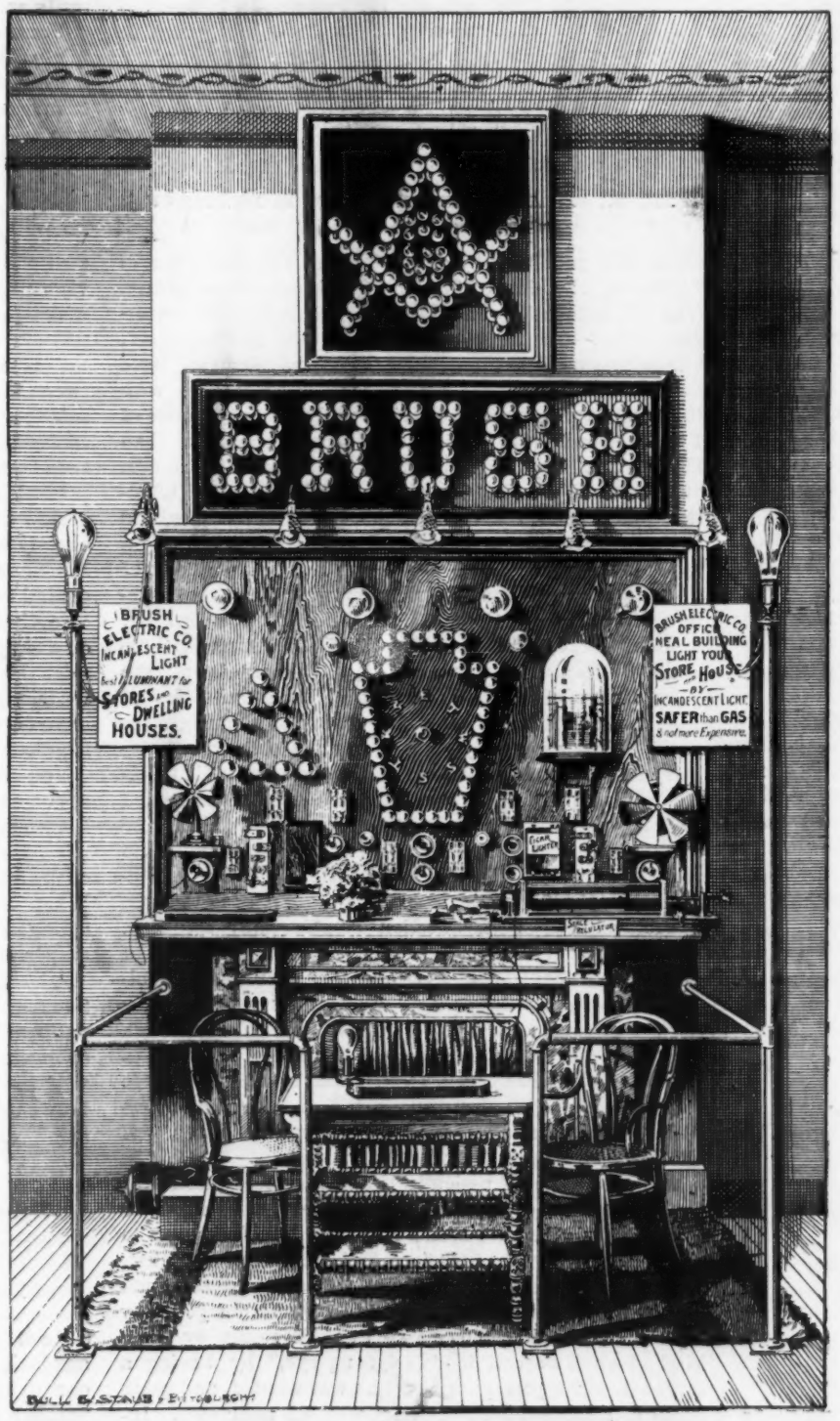
President Whitney made a verbal statement in which he presented some statistics showing the percentage of increase in traffic since the electric system was adopted on the different divisions: "Between Oct. 1 and Nov. 10 of this year, which is a fair time for comparison, because people are at home from the summer resorts, there was an increase of 73 per cent. in traffic on the Brookline, Allston electric lines over the corresponding days of last year. In Cambridge, where some prejudice exists against the extension of the present electric service, the increase for the same period was about 16 per cent. The directors, realizing the growing demands made upon the company, have already nearly completed a great power plant. The money spent on that great plant is the best expenditure the directors ever made. The essential thing is power. There is no limit to the business if we have the power to take care of it. The central power plant now being built will have an actual capacity of 10,000 h. p. It will have a chimney and power house sufficient for double that power. The only embarrassment that we now experience is from the lack of power. We are buying power from the Cambridge Electric Light Company and the Edison company, and would be glad to get double the amount that these companies are able to supply. All our troubles of last winter was due to lack of power. That, of course, will take time to remedy. We have several improvements in progress looking to the reduction of the noise made by motors. The gearing will be so changed and other things so improved that the noise will be next to nothing. There is no reason why our present electric system should not be extended to the towns of Malden, Melrose, Everett and the other towns in that section; also in Upham's Corner, Field's Corner and places in that section. There is no question at all but that within three years we will be called upon to carry 30 to 50 per cent. more people than at present." These words from President Whitney are a strong endorsement of the superior advantages of electric traction.

Exhibit of the Brush Electric Light Company of Baltimore, Md.

The Masonic fraternity of Baltimore, Md., has just concluded a very successful "Bazaar" in the Masonic Temple of that city. The object of this entertainment was to raise funds, which are to be used in the interest of the Baltimore Masons. The Temple had been very gaily decorated; a fine orchestra of musicians had been hired to entertain the guests during the evening, and in addition the management of the Brush Electric Light Company of Baltimore had been prevailed upon to make an electrical exhibition in the hall to attract the people. The electrical display had been announced as the big drawing card, and it is greatly to the credit of the Brush Company that it turned out to be such a success.

The accompanying cut is an illustration of the display, representing a number of those features which are characteristic of the Westinghouse alternating current system, under which the Baltimore company operates. Besides the 17 arc and about 200 incandescent lamps which the Brush company burned in the hall, the exhibit consisted of a stage regulator, a Shallenberger meter, an electric cigar lighter, which attracted especial attention, and on the table in front coils illustrating the Westinghouse converter system. Two lamps at the top of the rail in the front of the exhibit each held a 250 c. p. incandescent lamp operated by the alternating current. In the corner, on the left hand side of the display were shown several small batteries and an induction coil. From this the attendant at the exhibit gave the visitors, who desired it, shocks, and thus a good deal of amusement was afforded to the guests. The lettering, the compass, the keystone and other Masonic emblems were represented by incandescent lamps of various colored globes, and the effect of the entire exhibit was very beautiful. Over 50,000 people have visited the electrical display, it having been the first of its kind ever seen in Baltimore.

Since the reorganization of the Brush company in Baltimore the management has instituted some great improvements in the plant, and a good many more are contemplated. The power house has a boiler capacity of 2,800 h. p. The plant has now 16 engines, varying in horse power from 75 to 300; and two foundations for two Westinghouse compound engines are even now awaiting the new machines. The company operates chiefly the Westinghouse system of alternating arc and incandescent lighting. The management has only lately contracted for a number of new dynamos, and when they are all installed the Baltimore central station will have capacity of 20,000 incandescent and 1,500 arc lamps. Two 250-light Westinghouse alternating current arc dynamos are being put in the power house now, and two No. 3 alternating current incandescent dynamos are expected to arrive within a short time.



ELECTRICAL EXHIBIT AT BALTIMORE, MD.

The Discharge of Accumulators Left on Open Circuit.*

BY GASTON ROUX.

When it is not required to make use of a battery of accumulators during a certain period, what must one do to prevent them from being injuriously affected? That is a question which has often been put to me, and to which I have always replied: "Charge the battery to 'saturation,' and leave it to itself.' I am aware that this is not the opinion of every one, and that some recommend that accumulators should be charged to "saturation" and the liquid then emptied out, while others advise substituting pure water for the ordinary solution, and others still the substitution of concentrated acid for the ordinary solution. My opinion was based upon an experiment which I carry out each year at the Ecole de Physique et Chimie Industrielles de la Ville de Paris during the summer holidays. The experiment was repeated as usual this year, and I determined the exact amount of charge lost by the accumulators left on open circuit. The tests were made on two storage cells of the Julien type, having capacity of 200 ampère hours, which were separated from the remainder of the battery. The accumulators are provided with paraffine spray arresters. The cells are of glass and are contained in wooden boxes filled with sawdust and supported on oil insulators. The cells, therefore, are thoroughly well insulated. The solution has a density of 1.2 when the cells are fully charged, and contains 6 per cent. in volume of saturated sulphate of soda.

The two cells were charged to saturation on Aug. 5, discharged on Aug. 6, and recharged on the 7th of the same month. I then left them to themselves until Oct. 20, that is to say, for two months and 13 days, when they were discharged. The discharge was stopped both on Aug. 6 and Oct. 20, when the E.M.F. had fallen to 1.8 volts per cell. The quantity of electricity was found to be 233 ampère hours on Aug. 6 and 220 ampère hours on Oct. 20. Assuming that in each charge the accumulators stored the same quantity of electricity, we may conclude that the accumulators only lost on open circuit 13 ampère hours, or 6 per cent. of their charge during two and a half months. This result seems to me to prove that accumulators well made, well charged and well insulated are not injured by being left on open circuit. It also shows the good quality of these particular cells, and proves again that there is no local action between the active material and the antimony alloy supports. I should have liked to have carried out a similar test on accumulators with plain lead grids, but I had none at my disposal.

Edison on Electricity Direct from Coal.

Being asked last week by a reporter about future inventions in the electrical line, Mr. Edison replied: "Do you know, I have nothing to do with the future. My work, my thoughts, are entirely engrossed with the present. It is from the present that I must work out, or study out rather, inventions that can be easily applied to commercial advantage. I deal exclusively with the practical things of life and never try to dream useless dreams over an invention that will never benefit any one. I am now engaged on the vital question of electricity—viz., the way to obtain it direct without the aid of other motive power. It has been a study of mine for years, and I confess that I have not succeeded in making the invention. I shall never cease trying to unravel the problem.

"The man who makes this invention will solve the question of motor power. I would gladly acknowledge the greatness of any one who could do this, and hail him as the king of inventors. No selfish motives of not being first would keep me from acknowledging his greatness. No other invention would so benefit and revolutionize the world. At present we have to use coal to generate steam, and it in turn gives motor power to the dynamo which produces electricity. Only about 15 or 19 per cent. of the energy of coal is thus used. The result is an expensive and vast waste. Tons of coal are used upon vessels on one trip to Europe, but if electricity can be generated directly from the coal, then only a few basketfuls will be necessary to carry the biggest vessel across the ocean.

*From *l'Electricien*.

"Have I succeeded in making any headway? Just a little. I can get some electricity direct from coal, but it has no force to speak of. It is not the true force I am looking for. I do not dream over it, but I confess I spend many hours working over it.

"Think of it. Electricity directly from coal. It may sound like an echo of the millennium, but I do not think so. We have succeeded in using electrical force in many and various ways. But electricity can never be the motor of the world if another power is necessary to generate it. The expense is too great, and so the original power is preferable of course. Now, for a moment imagine the condition of things following this invention: Steam will become a thing of the past and the greatest and cheapest motor power, electricity, will be universally used. Some idea may be gained of the superior power of the new motors by stating that it will then only require three days to go to Europe, and only two or three days will be consumed in a railroad trip to California. The factory that I run, which now consumes a great quantity of coal daily, will need only a small basketful of coal to keep it going all day. Great factories that annually burn thousands of tons of coal will be run on several tons, say two or three, or a few more per annum, saving many thousands of dollars. The cost of living, the cost of goods, the cost of nearly everything will be reduced. It will cost nothing to make ice. It will be a revolution, not to throw any one out of employment, not to ruin any industry, but to benefit mankind and civilization in general."

The Electromagnet.*

BY PROF SILVANUS P. THOMPSON, D. SC., A. B., M. I. E. E.

ELECTROMAGNETIC MECHANISM.

The task before me to-night comprises the following matters: First, to speak of that particular variety of the electromagnet in which the iron core, instead of being attached to the coils, is movable, and is attracted into them. Secondly, to speak of the modes of equalizing the pull of electromagnets of various sorts over their range of action. Thirdly, to describe sundry mechanisms which depend on electromagnets. Lastly, to discuss the modes of prevention or diminution of the sparking which is so almost invariably found to accompany the break of circuit when one is using an electromagnet.

THE COIL-AND-PLUNGER.

First, then, let me deal with the apparatus wherein an iron core is attracted into a tubular coil or solenoid, an apparatus which, for the sake of brevity, I take the liberty of naming as the *coil-and-plunger*. Now, from quite early times, from 1822 at any rate, it was known that a coil would attract a piece of iron into it, and that this action resembled somewhat the action of a piston going into a cylinder—resembled it, I mean to say, in possessing an extended range of action. The use of such a device as the coil-and-plunger was even patented in this country in 1846 under the name of "a new electromagnet." Electromagnetic engines, or motors, were made on this plan by Page, and afterwards by others, and it became generally known

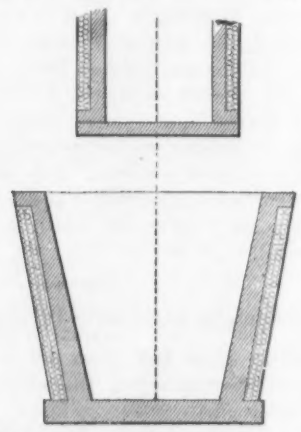


Fig. 57.—Hjorth's Electromagnetic Mechanism.

as a distinct device. But even now, if you inquire into the literature of the text-books to know what are the peculiar properties of the coil-and-plunger arrangement, you will find that the books give you next to no information. They are content to deal with the thing in very general terms by saying: Here is a sort of sucking magnet; the core is attracted in. Some books go so far as to tell you that the pull is greatest when the core is about half way in; a statement which is true in one particular case, but false in a great many others. Another book tells you that the pull is greatest at a point one centimetre below the centre of the coil, for plungers of all different lengths—which is quite untrue. Another book tells you that a wide coil pulls less powerfully than a narrow one; a statement which is true for some cases and not for others. The books also give you some approximate rules, which, however, are very little to the point. The reason why this ought to receive much more careful consideration is because in this mechanism of coil-and-plunger we have a real means not only of equalizing, but also of vastly extending the range of the pull of the electromagnet. Let us take a very simple example for the sake of contrasting the range of action of the ordinary electromagnet with the range of action of the coil-and-plunger.

Here are some numbers which are given in a paper with which I have long been familiar, a paper written by the late Mr. Robert Hunt in 1856, and read before the Institution of Civil Engineers, with that eminent engineer, Robert Stephenson, in the chair. Mr. Hunt discussed the various types of motors, and spoke of this question of the range of action. He named some experiments of his own in which the following was the range of action. There was a horseshoe electromagnet which at distance zero—that is, when its armature was in contact—pulled with a pull of 220 pounds; when the distance was made only $\frac{4}{1000}$th of an inch (4 mils), the pull fell to 90 pounds; and when the distance was increased to 20 mils ($\frac{1}{50}$th of an inch), the pull fell to only 36 pounds. The difference from 220 to 36 was within a range of $\frac{1}{50}$th of an inch. He contrasts this with the results given by another mechanism, not quite the simple coil-and-plunger, but a variety of electromagnet brought out

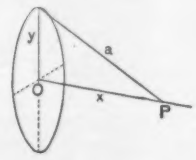


Fig. 58.—Action of Single Coil on Point Pole on Axis.

about the year 1845 by a Dane named Hjörth, living in Liverpool, wherein a sort of hollow, truncated cone of iron (Fig. 57), with coils wound upon it—a hollow electromagnet, in fact—was caused to act on another electromagnet, one being caused to plunge into the other. Now we have no information what the pull was at distance zero with this curious arrangement of Hjörth's, but at a distance of 1 inch the pull (with a very much larger apparatus than Hunt's) was 160 pounds, the pull at 3 inches was 88 pounds, at 5 inches 72 pounds. Here, then, we have a range of action going not over $\frac{1}{50}$th of an inch, but over 5 inches, and falling not from 220 to 36, but from 160 to 72, obviously a much more equable kind of range. At the Institution of Civil Engineers on that occasion a number of the most celebrated men, Joule, Cowper, Sir William Thomson, Mr. Justice Grove, and Professor Tyndall discussed these matters—discussed them up and down—from the point of view of range of action, and from the point of view of the fact that there was no means of working them at that time except by the consumption of zinc in a primary battery; and they all came to the conclusion that electric motors would never pay. Robert Stephenson summed up the debate at the end in the following words: "In closing the discussion," he remarked, "there could be no doubt from what had been said that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question commercially speaking. Without, however, considering the subject in that point of view, the mechanical applications seemed to involve almost insuperable difficulties. The power exhibited by electromagnetism, though very great, extended through so small a space as to be practically useless. *A powerful magnet might be compared, for the sake of illustration, to a steam engine with an enormous piston but with an exceedingly short stroke; such an arrangement was well known to be very undesirable.*"

Well, from the discussion in 1856—when this question of the length of range was so distinctly set forth—down to the present, there have been a large number of attempts to ascertain exactly how to design a long range electromagnet, and those who have succeeded have, as a general rule, not been the theorists; rather they have been men compelled by force of circumstances to arrive at their result by some kind of—shall we call it—"designing eye," by having a sort of intuitive perception of what was wanted, and going about it in some rough-and-ready way of their own. Indeed, I am afraid had they tried to get much light from calculations based on orthodox notions respecting the surface distribution of magnetism, and all that kind of thing, they would not have been much helped. There is our old friend, the law of inverse squares, which would of course turn up the first thing, and they would be told that it would be impossible to have a magnet that pulled equally through any range, because the pull was certain to vary inversely according to the square of the distance. I noticed that, in a report of my second lecture in one of the London journals, I am announced to have said that the law of inverse squares did not apply to electric forces. I beg to remark I have said no such thing. It is well to be precise as to what one does say. There has been a lively discussion going on quite lately whether sound varies as the square of the distance—or rather, whether the intensity of it does—and the people who dispute on both sides of the case do not seem to know what the law of inverse square means. I have also seen the statement made last week in the columns of *The Times*, by one who is supposed to be an eminent authority on eyesight, that the intensity of the color of a scarlet geranium varies inversely with the square of the distance from which you see it. More utter nonsense was never written. The fact is, the law of inverse squares, which is a perfectly true mathematical law, is true not only for electricity, but for light, for sound, and for everything else, provided it is applied to the one case to which a law of inverse squares is applicable. That law is a law expressing the way in which action at a distance falls off when the thing from which the action is proceeding is so small compared with the distance in question that it may be regarded as *a point*. The law of inverse squares is the law universal of action proceeding from a point. The music of an orchestra at 10 feet distance is not four times as loud as at 20 feet distance; for the size of an orchestra cannot be regarded as a mere point in comparison with these distances. If you can conceive of an object giving out a sound, and the object being so small in relation to the distance at which you are away from it that it is a point, the law of inverse squares is all right for that, not for the intensity of your hearing, but for the intensity of that to which your sensation is directed. In no case, however, are sensations absolutely proportional to their causes. When the magnetic action proceeds from something so small that it may be regarded as a point compared with the distance, then the law of inverse squares is necessarily and mathematically true.

You may remember that I produced an apparatus (Fig. 27) which I said was the only apparatus hitherto devised which did directly prove, experimentally, the law of inverse squares for the case of a magnetic pole. There was in it a pole, virtually a point at a considerable distance from a small magnetic needle, which was also virtually a point.

The law of inverse squares is true; but it is not what one works with when one deals with electromagnets having ends of a visible size, acting on armatures themselves of visible sizes, and quite close to them. If you take a case which never occurs in practice, an armature of hard steel, permanently magnetized, so far away from an electromagnet (or rather from one pole only) that the distance between the one pole and the armature on which you are acting is so very great compared with each of them that each of them may be regarded by comparison as a point, then the law of inverse squares may be rightly applied, but not unless.

Now we want to arrive at a true law. We want to know exactly what the law of action of the coil-and-plunger is. It is not a very difficult thing to work out, provided you get hold of the right ideas. We must begin with a simple case, that of a short coil consisting of but one turn, acting on a single point pole. From this we may proceed to consider the effect on a point pole of a long tube of coil. Then we may go on to a more complex case of the tube coil acting on a very long iron core; and last of all from the very long iron core we may pass to the case of a short core.

You all know how a long tube of coil such as this will act on an iron core. Let us make an experiment with it. I turn on the current so that it circulates around the coil along the tube, and when I hold in front of the aperture of the tube this rod of soft iron, it is sucked into the coil. When I pull it out a little way it runs back, as with a spring. The current happens to be a strong one—about 25 ampères; there are about 700 turns of wire on the coil. The rod is about one inch in diameter and 20 inches long. So great is the pull that I cannot pull it entirely out. The pull was very small when the rod was outside, but as soon as it gets in it is pulled actively, runs in and settles down with the ends equally protruding. The tubular coil I have been using is about 14 inches long; but now let

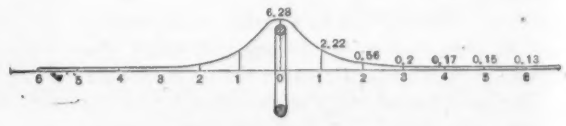


Fig. 59—Action along Axis of Single Coil.

us consider a shorter coil. Here is one only half an inch from one end to the other, but I have one somewhere still shorter, so short that the length, parallel to the axis, is very small compared with the diameter of the aperture within. The wire on it consists of but one single turn. Taking such a coil, treating it as only one single ring, with the current going once round, in what way does it act on a magnet that is placed on the axis? First of all, take the case of a very long permanently magnetized steel magnet, so long, indeed, that any action on the more distant pole is so feeble that it may be disregarded altogether and only one pole, say the north pole, is near the coil. In what way will that single turn of coil act on that single pole? This is the rule, that the pull does not vary inversely as the square of the distance, nor as any power at all of the distance measured straight along the axis, but inversely as the cube of the slant distance. Let the point O in Fig. 58 represent the centre of the ring, its radius being y. The line $O\,P$ is the axis of the ring, and the distance from O to P we will call x. The slant distance from P to the ring we call a. Then the pull on the axis toward the centre of this coil varies inversely as the cube of a. That law can be plotted out in a curve for the sake of observing the variations of pull at various points along the axis. Allow me to draw your attention to Fig. 59, which represents a section or edge view of the coil. At various distances right and left of the coil are plotted out vertically the corresponding force, the calculations being made for a current of 10 ampères, circulating once around a ring of one centimetre radius. The force with which such a current acts on a magnetic pole of unit strength placed at the central

* Cantor Lectures, No. 4, continued from The Electrical World, Nov. 15, 1890.

point in 6.28 dynes. If the pole is moved away down the axis, the pull is diminished; at a distance away equal in length to the radius it has fallen to 2.22 dynes. At a distance equal to twice the radius, or one diameter, it is only 0.56 dynes, less than one-tenth of what it was at the centre. At two diameters it has fallen to 0.17 dyne, or less than three per cent.; and the force at three diameters is only about two per cent. of that at the centre.

If, then, we could take a *very* long magnet, we may utterly neglect the action on the distant pole. If I had a long steel magnet with the south pole five or six feet away, and the north pole at a point three diameters (*i. e.*, six centimetres in this case) distant from the mouth of the coil, then the pull of the current in one spiral on the north pole three diamters away would be practically negligible; it would be less than two per cent. of what the pull would be of that single coil when the pole was pushed right up into it. But now, in the case of the tubular coil, consisting of at least a whole layer of turns of wire, the action of all of the turns has to be considered. If the nearest of the turns of wire is at a distance equal to three diameters, all the other turns of wire will be at greater distances, and, therefore, if we may neglect such small quantities as two per cent. of the whole amount, we may neglect their action also; for it will be still smaller in amount. Now, for the purpose of arriving at the action of a whole tube of coil, I will adopt a method of plotting devised by Mr. Sayers. Suppose we had a whole tube coiled with copper wire from end to end, its action would be practically the same as though the copper wire were gathered together in small numbers at distant intervals. If, for example, I count the number of turns in a centimetre length of the actual tubular coil, which I used in my first experiment, I find there are four. Now if, instead of having four wires distributed over the centimetre, I had one stout wire in the middle of that space to carry four times the current, the general effect would be the same. This diagram (Fig. 60) is calculated out on the supposition that the effect will be not greatly different if the wires were aggregated in that way, and it is easier to calculate. If, beginning at the end of the tube marked *A*, we take the wires over the first centimetre of length and aggregate them, we can draw a curve, marked 1, for the effect of that lot of wires. For the next lot we could draw a similar curve, but instead of drawing it on the horizontal line we will add the several heights of the second curve on to those of the first, and that gives the curve marked 2; for the third part add the ordinates of another similar curve, and so gradually build up a final curve for the total action of this tubular coil on a unit pole at different points along the axis. This resultant curve begins about 2½ diameters away from the end, rises gently, and then suddenly, and then turns over and becomes nearly flat with a long level back. It does not rise any more after a point about 2½ diameters along from *A*; the curve at that point becomes practically flat, or does not vary more than about one per cent., however long the tube may be. For example, in a tubular coil one inch in diameter and 20 inches long, there will be a uniform magnetic field for about 15 inches along the middle of the coil. In a tubular coil 3 centimetres in diameter and 40 centimetres long, there will be a uniform magnetic field for about 32 centimetres along the middle of the coil. The meaning of this is that the value of the magnetic forces down the axis of that coil begins outside the mouth of the tube, increases, rises to a certain maximum amount a little within the mouth of the tube, and after that is perfectly constant nearly all the way along the tube, and then falls off symmetrically as you get to the other end. The ordinates drawn to the curve represent the forces at corresponding points along the axis of the tube, and may be taken to represent not simply the magnetizing force, but the pull on a magnetic pole at the end of an indefinitely long, thin steel magnet of fixed strength.

The rule for calculating the intensity of the magnetic force at any point on the axis of the long tubular coil within this region where the force is uniform is:

$$H = \frac{4}{10}\pi \times \text{the ampère-turns per centimetre of length.}$$

And, as the total magnetizing power of a tubular coil is proportional not only to the intensity of the magnetic force at any point, but also to the length, the integral magnetizing effect on a piece of iron that is inserted into the coil may be taken as practically equal to $\frac{4}{10}\pi \times$ the total number of ampère-turns in that portion of the tubular coil which surrounds the iron. If the iron protrudes as much as three diameters at both ends, the total magnetizing force is simply $\frac{4}{10}\pi \times$ the whole number of ampère-turns.

Now that case is of course not the one we are usually dealing with. We cannot procure steel magnets with unalterable poles of fixed strength. Even the hardest steel magnet, magnetized so as to give us a permanent pole near or at the end of it—quite close up to the end of it when you put it into a magnetizing coil—becomes by that fact further magnetized. Its pole becomes strengthened as it is drawn in, so that the case of an unalterable pole is not one which can actually be realized. One does not usually work with steel; one works with soft-iron plungers which are not magnetized at all when at a distance away, but become magnetized in the act of being placed at the mouth of the coil, and which become more highly magnetized the further they go in. They tend, indeed, to settle down, with the ends protruding equally, for that is the position where they most nearly complete the magnetic circuit; where, therefore, they are most completely and highly magnetized. Accordingly we have this fact to deal with, and whatever may be the magnetizing forces all along the tube, the magnetism of the entering core will increase as it goes on. We must therefore have recourse to the following procedure: We will construct a curve in which we will plot not simply the magnetizing forces of the spiral at different points, but the product of the magnetizing forces into the magnetism of the core which itself increases as the core moves in. The curve with a flat top to it corresponds to an ideal case of a single pole of constant strength. We wish to pass from this to a curve which shall represent a real case, with an iron core. Let

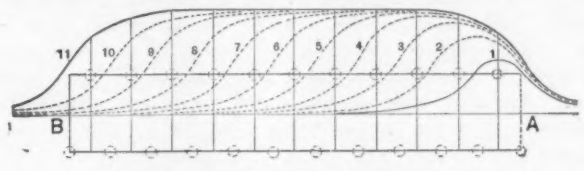


FIG. 60.—ACTION OF TUBULAR COIL.

us still suppose that we are using a very long core, one so long that when the front pole has entered the coil the other end is still a long way off. With an iron core of course it depends on the size and quality of the iron as to how much magnetism you get for a given amount of magnetizing power. When the core has entered up to a certain point you have all the magnetizing forces up to that point acting on it; it acquires a certain amount of magnetism, so that the pull will necessarily go on increasing and increasing, although the intensity of the magnetic force from point to point along the axis of the coil remains the same, until within about two diameters from the far end. Although the magnetic force inside the long spiral remains the same, because the magnetism of the core is increasing, the pull goes on increasing and increasing (if the iron does not get saturated) at an almost uniform rate all the way up until the piece of iron has been poked pretty nearly through to the distant end. In Fig. 61, a tubular coil, *B A*, is represented. Suppose a long iron core is placed on the axis to the right, and that its end is gradually brought up toward *B*. When it arrives at *X*, the pull becomes sensible, and increases at first rapidly, as the core enters the mouth of the tube, then gently, as the core travels along attaining a maximum, *C*, about at the further end, *A*, of the tube. When it approaches to the other end, *A*, it comes to the region where the magnetizing force falls off, but the magnetism is still going on increasing, because something is still being added to the total magnetizing power, and these two effects nearly balance one another, so that the pull arrives at the maximum. This is the highest point, *C*, on the curve; the greatest pull occurring just as the end of the iron core arrives at the bottom or far end of the tubular coil; from which point there is a very rapid falling off. The question of rapidity of descent from that point depends only on how long the core is. If the core is a very long one, so that its other pole is still very far away, you have a long, slow descent going on over some three

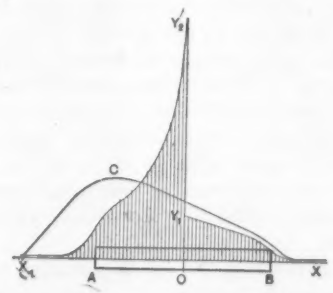


FIG. 61.—DIAGRAM OF FORCE AND WORK OF COIL-AND-PLUNGER.

diameters, and gradually vanishing. If, however, the other pole is coming up within measurable distance of *B*, then the curve will come down more rapidly to a definite point, X_1. To take a simple case where the iron core is twice as long as the coil, its curve will descend in pretty nearly a straight line down to a point such that the ends of the iron rod stand out equally from the ends of the tube.

Precisely similar effects will occur in all other cases where the plunger is considerably longer than (at least twice as long as) the coil surrounding it. If you take a different case, however, you will get another effect. Take the case of a plunger of the same length as the coil, then this is what necessarily happens. At first the effects are much the same; but as soon as the core has entered about half, or a little more than half, its length you begin to have the action of the other pole that is left protruding outside tending to pull the plunger back; and although the magnetizing force goes on increasing the further the plunger enters, the repulsion exerted by the coil on the other pole of the plunger keeps increasing still faster as this end nears the mouth of the coil. In that case the maximum will occur at a point a little further than half way along the coil, and from that point the curve will descend and go to zero at *A*; that is to say, there will be no pull when both ends of the plunger coincide with the two ends of the coil. If you take a plunger that is a little shorter than the coil, then you find that the attraction comes down to zero at an earlier period still. The maximum pull occurs earlier, and so does the reduction of the pull to zero; there being no action at all upon the short core when it lies wholly within that region of the tube within which the intensity of the magnetic force is uniform. That is to say, for any portion of this tube corresponding to the flat top of the curve of Fig. 60, if the plunger of iron is so short as to lie wholly within that region, then there is no action upon it; it is not pulled either way. Now these things can be not only predicted by the help of such a law as that, but verified by experiment. Here is a set of tubular coils which we use at the Finsbury Technical College for the purpose of verifying these laws. There is one here about nine inches long, one about half that length, another just a quarter. They are all made alike in this way, that they have exactly the same weight of copper wire, cut from the same hank, upon them. There are, of course, more turns on the long one than on the shorter, because with the shorter ones each turn requires, on the average, a larger amount of wire, and therefore the same weight of wire will not make the same number of windings. We use that very simple apparatus, a Salter's balance, to measure the pull exerted down to different distances on cores of various lengths. You find in every case the pull increases and becomes a maximum, then diminishes. We will now make the experiment, taking first a long plunger, roughly about twice as long as the coil. The pull increases as the plunger goes down, and the maximum pull occurs just when the lower end gets to the bottom; beyond that the pull is less. Using the same plunger with these shorter coils, one finds the same thing, in fact more marked, for we have now a core which is more than twice the length of the coil. So we find, taking in all these cases, that the maximum pull occurs not when the plunger is half way in, as the books say, but when the bottom end of it is just beginning to come out through the bottom of the coil that we are using. If, however, we take a shorter plunger, the result is different. Here is one just the same length as the coil. With this one the maximum pull does occur when the core is about half way in; the maximum pull is just about at the middle. Again, with a very short core—here is one about one-sixth of the length of the coil—the maximum pull occurs as it is going into the mouth of the coil; and when both ends have gone in so far that it gets into the region of equable magnetic field there is no more pull on one end than on the other; one end is trying to move with a certain force down the tube, and the other end is trying to move with exactly equal force up the tube, and the two balance one another. If we carry that to a still more extreme case, and employ a little round ball of iron to explore down the tube, you will find this curious result, that the only place where any pull occurs on the ball is just as it is going in at the mouth. For about half an inch in the neck of the coil there is a pull; but there is no pull down the interior of the tube at all, and there is no measurable pull outside.

Now these actions of the coil on the core are capable of being viewed from another standpoint. Every engineer knows that the work done by a force has to be measured by multiplying together the force and the distance through which its point of application moves forward. Here we have a varying force acting over a certain range. We ought, therefore, to take the amount of the force at each point, and multiply that by the adjacent little bit of range, averaging the force over that range, and then take the next value of force with the next little bit of range, and so consider in small portions the work done along the whole length of travel. If we call the length of travel x the element of length must be called dx. Multiply that by f, the force. The force multiplied by the element of length give us the work, dw, done in that short range. Now the whole work over the whole travel is made up of the sum of such elements all added together; that is to say, we have to take all the various values of f, multiply each by its own short range dx, and the sum of all those, writing $\int$ for the sum, would be equal to the sum of all the work; that is to say, the whole work done in putting the thing together will be written:

$$w = \int f\,dx.$$

Now what I want you to think about is this: Here, say, is a coil, and there is a distant core. Though there is a current in the coil, it is so far away from the core that practically there is no action; bring them nearer and nearer together; presently they begin to act on one another; there is a pull, which increases as the core enters, then comes to a maximum, then dies away as the end of the core begins to protrude at the other side. There is no further pull at all when the two ends stand out equally. Now there has been a certain total amount of work done by this apparatus. Every engineer knows that if we can ascertain the force at every point along the line of travel the work done in that travel is readily expressed by the area of the force-curve. Think of the curve *X C X*, in Fig. 61, the ordinates of which represent the forces. The whole area underneath this curve represents the work done by the system, and therefore represents equally the work you would have to

do upon it in pulling the system apart. The area under the curve represents the total work done in attracting in the iron plunger, with a pull distributed over the range $x\ x_1$.

(To be continued.)

The Working of an Electrolytic Copper Refinery.*

BY DR. G. GORE, F. R. S.

The entire economy of working depends essentially upon cheapness of motive power and minimum investment of capital, and nearly every attempt to improve the process, in the direction of such economy, involves a choice between two evils. For instance, if we try to save horse power by enlarging the electrodes and adding to the number and size of vats in series, we rapidly increase the loss of interest upon capital expended in stock of copper, solution, plant, working space, etc. If we increase the density of current with the intention of working more rapidly with the same stock of copper, solution, etc., we increase the loss of energy by causing polarization, and run a risk of depositing impure copper. And if we attempt to diminish the resistance by placing the electrodes nearer together, or by quickly stirring the solution, we get dirt upon the cathodes, or short circuiting occurs; and if we endeavor to decrease it by considerably heating the liquid, we rapidly increase the chemical corrosion of the deposited metal, and quickly alter the chemical composition of the liquid; or if we diminish resistance by large additions of acid, we promote chemical corrosion, polarization and separation of gases.

Difference of potential required is a large element in the economical deposition of copper. While the same number of ampères of current passing through the ordinary solution deposits the same amount of copper in all cases, the necessary degree of difference of potential to overcome resistance, etc., varies in different cases, and the greater this difference the larger the cost; double the potential requires double the motive power. It is desirable, therefore, to lower the difference of potential as much as possible by diminishing the resistance throughout the circuit and by avoiding all polarization and counter-electromotive force.

The degree of electromotive force required varies with every different kind of solution, and consequently of anode. It varies according as the anode is composed of pure copper, "black copper," or "copper matte," and whether the anode is clean, or covered with an adhesive badly conducting coating; it is also much greater when gas is evolved at either electrode.

Influence of Impure Anodes upon the Liquid.—I will only speak of some of those substances which are more or less likely to be present in "black copper," "pimple copper," "Chili bars," "blister copper," containing from 89 to 98 per cent. of copper, and in cruder regulus of reduced pyrites of iron and copper. Those impurities include antimony, arsenic, bismuth, cadmium, carbon, cobalt, gold, iron, lead, manganese, platinum, silver, tin, zinc, suboxide of copper, sulphides of iron, copper and silver in the particles of unreduced pyrites of those metals, alumina, lime, magnesia, silica and alkalies in the inclosed portions of slag. Black copper has been found to contain "1.23 per cent. of arsenic, 1.0 of iron, .54 of sulphur, .4 silver, and .011 of gold" (*Engineering*, 1885, p. 306).

In an acidulated solution of blue vitriol, the following of those substances, viz., cadmium, cobalt, iron, zinc, sulphide of iron, alumina, magnesia and alkalies of the slag, dissolve readily; antimony, arsenic, bismuth, tin and silica dissolve imperfectly and partly fall to the bottom; carbon, gold, platinum and sulphur from the pyrites are insoluble and precipitate entirely; lead is converted into sulphate, which almost wholly precipitates; silver is changed into chloride, provided a soluble chloride is present, which is usually the case, and is entirely thrown down; suboxide of copper, and the sulphides of copper and of silver also precipitate. The lime is all changed into sulphate, a small quantity only of which enters into solution while the remainder subsides.

One effect of using an impure metal or an alloy as an anode is, that its different constituents are corroded unequally, both by the ordinary chemical action of the liquid and by the influence of the current. By both these actions the most electro-positive metals are attacked first, and the others in succession, in accordance with the thermal law which governs such actions; and those which are not corroded at all, together with those which form insoluble compounds, either remain upon the surface as a coating, or fall to the bottom as mud. In consequence of this irregularity of action, the anodes are often corroded deeply in places, even while containing much metallic copper in their coatings, become rotten, and pieces of them fall to the bottom, and this occurs the most with very impure metal, and especially with cupreous matte. When the anodes are made by fusion of copper pyrites, they often swell on the sides toward the cathode after a few days of electrolytic action. If also the liquid is not kept homogeneous, impure ones are rapidly corroded, and sometimes cut through at the surface of the solution and fall to the bottom.

If arsenic is present, it partly dissolves as arsenious or arsenic acid, and gradually unites with some of the constituents of the mud to form insoluble compounds; arsenious acid is sparingly, and arsenic acid freely, soluble. It also partly forms arseniates upon the anode, which are non-conductors, and by adhering to that electrode offer resistance to the current.

Antimony partly dissolves, especially in acid solutions, and partly forms an insoluble basic salt, some of which adheres to the anode, oxidizes and increases in weight, and some falls to the bottom; any oxy-salt of antimony appears as a white cloudiness when the liquid is sufficiently dilute.

Bismuth behaves much like tin and antimony; it partly forms an insoluble basic salt, which precipitates, and partly dissolves an acid salt, which ultimately also becomes basic and falls.

Tin behaves much like antimony; it forms a mixture of proto-salt and basic salt, some of which adheres to the anode and some dissolves; the proto-salt is white when dry, and absorbs oxygen from the air rapidly to form persalt. The presence of dissolved tin in a neutral solution is said to greatly improve the quality of the separated copper, without the tin itself being deposited; this, however, probably only occurs under particular conditions, because in some experiments I made for the purpose this effect did not take place. The presence of tin in the anode increases the electromotive force of the current, because tin is more electro-positive than copper in dilute sulphuric acid.

Lead, being also more electro-positive than copper, is attacked before it, and aids the electromotive force; but its sulphate, being very insoluble, falls nearly wholly to the bottom, and only a trace is dissolved. There is but little risk of lead being deposited with copper, not only because its sulphate is so very insoluble, but also because lead is electro-positive to that metal. Lead, by being electrolytically corroded in place of copper, and uniting with acid to form an insoluble salt, diminishes the amount of copper and acid in solution.

If the anode contains metallic iron and manganese, those metals are dissolved before the copper, and being more electro-positive, assist the current; they dissolve as proto-salts, and subsequently become oxidized to some extent, but not completely, to persalts by contact with the air. If, however, the current is very much stronger than that usually employed in refining copper, these proto-salts are also oxidized to persalts at the anode; and in any case their persalts are reduced to proto-salts at the cathode by the current and cause great waste of power. The only way to prevent waste of energy in deoxidizing persalts at the cathode is to keep those salts out of the solution. Iron by dissolving in place of some of the copper at the anode, takes up some of the acid, forms green vitriol, and diminishes the solvent power of the water and the amount of copper in solution.

Any suboxide of copper in the anode, being a non-conductor, falls to the bottom, and is subsequently slowly oxidized and dissolved as cupric sulphate by the free acid. If the anode contains much cupreous sulphide, some of it is decomposed by the current, its metal dissolving while its sulphur separates and subsides. If its amount is small (as it usually is in "black copper"), being a very inferior conductor, it is unaffected by the current, and falls to the bottom as fast as the metal around it is dissolved.

In an anode containing copper, copper oxides and sulphides, the current goes most by the path of least resistance, *i. e.*, very largely by the metal, very little by the sulphides and much less by the oxides. If, therefore, the anode contains very little sulphide or oxide, the whole of the current travels through the copper, and the oxide and sulphide fall to the bottom; but if it contains much sulphide some of the current passes through it. At the same time, independently of the action of the current, the liquid is always acting chemically upon each of these substances, whether they form part of the anode or of the sediment.

It is evident that when the anode contains a large variety of impurities the chemical actions going on at its surface must be numerous and exceedingly complex, and modify each other, and make it very difficult to accurately describe them. One effect of these numerous impurities is to cause an almost infinite number of local electric currents all over the anode, attended by corrosion and solution of all the more positive substances without the aid of the external current, thus gradually neutralizing the free acid, and saturating the water with metallic salts.

Influence of the Impurities upon Current.—Provided the anodes are wholly metallic, their lower degree of electric conductivity due to impurities has very little effect upon the total resistance of the circuit, because the resistance of the solution is so very much greater. Consequently, also, it has but little effect upon the kind of dynamo required.

Impurities in the anode, however, have in some cases a great effect upon the electromotive force and upon the strength of current, either by giving rise to polarization and counter-electromotive force, or by the formation or accumulation of badly-conducting substances upon the anode. The greater the number of impurities also the greater the risk of waste of energy.

It is a fact that the electromotive force, and consequently also the strength of current, is increased when the anodes contain as impurities metals such as zinc, cadmium, manganese, or iron, which are more electro-positive than copper in the particular liquid, because they constitute with the copper cathode a voltaic couple sending a current in the same direction as the working one. But this assistance to the current, except with iron pyrites, is usually so very small that it is hardly observable, and the advantage of it more than counterbalanced by disadvantages. The presence of iron in the anode aids the current to only a small extent, but that of zinc helps it more.

Usually when fresh anodes are put in, the resistance of the vat gradually rises to a maximum, but when the film of impurities is removed from them the resistance falls at once slightly; it also usually increases with the thickness of the coating, but only slowly because the layer is porous and saturated with the solution. The coating acts chiefly by preventing ready access of unexhausted liquid, and thus promotes polarization.

When the solution contains persalts of iron or manganese those salts are reduced to proto-salts at the cathode, and a portion of the current is continually wasted in reducing them, instead of being wholly employed in separating copper, and the copper costs more to refine than when no iron or manganese is present. As long as there is sufficient persalt of iron in the liquid, no hydrogen is evolved at the cathode. With a copper-depositing solution containing much salt of iron, the difference of potential of plates of pure copper of a single vat has been found by experiment to be .22 volt, with an anode of black copper .25 volt, and with one of copper pyrites .5 volt, and when the solution was deficient in free acid, it was .35 volt with black copper, and .75 volt with copper pyrites (Kiliani, *Engineering*, Vol. XL., 1885, p. 306).

Effect of Impurities of the Liquid upon Purity of the Deposit.—The electrolyte is always less impure than the anode, because various of the impurities of the latter are either loosened by corrosion of the surrounding metal, and separate and fall to the bottom unchanged; or they are separated from their compounds by chemical or electro-chemical decomposition and subside; or they are converted by chemical action into insoluble compounds, which precipitate.

The more impure the anode, the less pure usually is the electrolyte. In addition to the proper constituents of the liquid, viz., blue vitriol, sulphuric acid, and water, there may be present in a dissolved state the sulphates of iron, zinc, manganese, cadmium, cobalt, aluminum, magnesium, calcium, potassium and sodium, basic sulphates of antimony, tellurium, bismuth and tin, and arsenious or arsenic acid.

By far the largest in amount of these dissolved impurities is the sulphate of iron; but the most objectionable ones are the compounds of arsenic, antimony and bismuth, because they are the most likely to yield their metals at the cathode, and thus affect the purity and quality of the deposited copper.

During the process of deposition the electrolyte continually becomes more impregnated with impurities, especially with iron, and, in much less degrees, also with zinc, manganese, cobalt, nickel, tin, arsenic, antimony, bismuth, aluminum, calcium (within small limits), magnesium, potassium and sodium, and gradually poorer in free acid, and, sooner or later, requires to be purified.

Influence of Impurities of the Liquid upon the Current.—The greater the number of impurities in the electrolyte, the greater the risk of waste of electric energy. All ordinary sulphate of copper solution used in the electrolytic refining of copper contains, after a time, a greater or less proportion of dissolved ferrous sulphate, and this substance gradually combines with the oxygen of the air and becomes persalt. In such a mixture there is liable to occur a considerable waste of current and deficiency of deposited copper—first, because much of the electric energy is wasted in deoxidizing the persalt at the cathode; and second, because a solution of persalt of iron corrodes and dissolves copper; the free acid therefore decreases, and the liquid acquires greater specific gravity. The presence of green vitriol, however, prevents polarization at the anode, because it absorbs oxygen.

In a solution of green vitriol partly oxidized by the air, and being suitably electrolyzed with platinum electrodes, a mixture of iron and hydrogen is deposited at the cathode, and persalt is formed at the anode; and, owing to absorption of oxygen from the air, the proportion of persalt increases.

Purity of the Deposited Copper.—It is a mistake to suppose that electro-deposited copper must be pure; if it has been deposited rapidly from an impure solution it may be very impure.

The purest electro-deposited copper is apt to contain traces of tellurium, bismuth and silver. These have been detected by photographing the spectrum of the copper. The presence of the first two of these would be due either to the density of the current at the cathode being too great, the liquid insufficiently stirred or the proportion of copper being too small, or to all these causes combined; but most likely to a combination of the first and second. The presence of silver may be due to absence of soluble chlorides or to sediment falling from the anode.

Of all the various circumstances already described which tend to produce purity of the copper the most important are: 1. Absence *in solution* of all the metals which are the most readily deposited with it; these are silver, bismuth, antimony, arsenic and tin; 2, using a sufficiently moderate density of current at the cathode; 3, keeping the solution

* Extract from the new volume of *The Electrician* Series, entitled "The Electrolytic Separation of Metals," by Dr. G. Gore. London, *The Electrician* Printing and Publishing Company.

perfectly clear and well circulated; and 4, not allowing any of the mud from the anode to touch the cathodes. All other conditions being alike, the most slowly deposited metal is the most pure.

There is usually not much risk of depositing any other metal than copper (and silver or bismuth if in solution) under the ordinary conditions of working when the density of current does not exceed five ampères per square foot, or the rate of deposition is not more than 70.7 grains per square foot per hour, and the increase of thickness is not greater than 1.07 millimetres, or .04 of an inch per week of 156 hours. At Stolberg, with an impure solution and a density of current of 1.482 ampères per square foot, the purity of the deposited copper is stated to be "99.92 and 99.95 per cent. in two analyses." One source of impurity is fine powder from the anodes diffused in the liquid.

The difference of purity of the deposit obtained with different qualities of anodes depends very little upon the electric conductivity of the metal, because with every quality of copper the large mass of anode has vastly less resistance than the electrolyte; but it depends very greatly upon the kind of impurities. If the impurities are soluble and readily deposited along with the copper, it is then necessary to reduce the speed of deposition, but this greatly increases the cost. According to a German writer (Dingler's *Polytechnisches Journal*, Vol. CCLV., p. 531), the copper deposited at the Oker refinery is extremely perfect, while that of some English electrolytic refineries is less so; probably the latter had been too rapidly deposited. Some samples of American-deposited copper have also been found to be impure. A minute proportion of antimony or bismuth destroys the good qualities of copper.

Cost of Electrolytic Refining.—The cost of refining copper by electrolysis varies with the magnitude of the installation, and depends essentially upon the expense of motive power, and of interest upon invested capital; also largely upon the degree of "commercial efficiency" of the dynamo, and upon the kind and amount of impurities in the crude metal, which are continually varying, because the composition of each batch of unrefined copper differs. The larger the proportion of foreign metals, which are easily deposited with the copper, and the purer the refined copper required, the greater the cost of the process, because it must be conducted more slowly. The cost when anodes composed of the unreduced sulphides of copper and iron are employed instead of metallic copper, as in "Marchese's process," is considerably different.

Where motive power or fuel is cheap, advantage is taken of the circumstance to economize the expenditure upon vats and copper, by using it more freely. At Casarza, where water power is cheap, the proportion of copper deposited is 1.4 pounds per horse power per hour; at Pembrey, where coal is cheap, it is 2.6 pounds; but at Hamburg, where motive power and fuel are dear, it is 6.87 pounds. The amount of electric energy and of horse power consumed in depositing the same weight of copper differs in nearly every electrolytic refinery. Where coal is cheap, and the process is conducted on a large scale, with a good steam engine, at least 110 indicated horse power is obtained during one week by the consumption of 50 tons of coal, and with good dynamos will deposit 20 tons of copper per week, at a cost of £20. The interest upon capital invested in plant, etc., during the same period will amount to about a similar sum. Or, if we reckon the cost of one mechanical horse power at one penny per hour, the cost of such power for electrolytic refining of copper is about one farthing per pound of that metal refined. Difference of potential required to overcome resistance and polarization is also an element in calculating the cost of depositing a given amount of copper, because double the electromotive force expended costs quite double the money.

The chief elements of cost are: 1. Interest upon capital expended upon copper, electrolyte, vats, steam engine, boiler, dynamo and other plant. 2. Fuel, water and oil for the engine. 3. Rent and taxes. 4. Labor. 5. Depreciation of steam engine, boiler, dynamos, vats, etc. 6. Incidental expenses.

The total stock of copper required in order to refine a given amount of that metal per day or week varies in different works. In each refinery, besides the amount of copper in the vats, there is at least an equal quantity in the form of main conductors, raw copper for making anodes, new anodes ready for immersion, and residues of old anodes, also the stock of refined copper. The value of the stock of copper alone in one of the installations at Hamburg has been estimated at "£8,000." Practically, to refine 30 tons a week of ordinary "Chili bars," with a current density of 8 or 10 ampères per square foot, requires a total stock of about 400 tons of copper, which, at £50 a ton, costs £20,000, to which we must add about £10,000 for plant and premises.

A number of workmen are necessary, probably about twenty, working day and night, when depositing thirty tons of copper per week, to manipulate the electrodes, examine the vats, and attend to the steam engine and dynamo, melt and cast anodes, wash dirty ones, etc. A chemical analyist is also employed to analyze the copper and the electrolyte. As stoppages in the process do not often occur, they are not a large element of expense; there is, however, the cost of occasionally emptying the vats, evaporating and purifying the solution, collecting and treating the mud, etc.

The cost of one of the latest forms of dynamo for electrolytic refining of copper by Messrs. Siemens & Halske, viz.: their "H C[11]" type, constructed to give 1,000 ampères at a difference of potential of 60 volts, was "£420," and that of a 50-unit one, by Messrs. Chamberlain & Hookman, giving 500 ampères at 100 volts, about £400. With large vats, and large currents of low electromotive force, the cost for the same rate of deposition is less, but that of the dynamo and conductors is greater than with small vats and small currents of higher electromotive force. A vat containing one cubic metre costs "about 130 francs," and one of three cubic metres "double that sum." The vats at Biache cost "350 francs each." One cubic metre of the ordinary copper solution costs "about 70 francs."

The total cost of M. Hilarion Roux's installation at Marseilles, including the baths, dynamo and steam engine to refine "250 kilogrammes per day" (= 89¼ tons yearly), is stated to have been "£1,000," and the amount of invested capital "£5,000 to £6,000." The Società Anonima Italiana di Miniere di Rame e di Elettro-Metallurgia," in Genoa, whose works are at Casarza, was established with a capital of 4.8 million marks (= £240,000) (Dingler's *Polytechnisches Journal*, 1885, Vol. CCLV., p. 201).

It might be supposed that the silver and gold recovered constitutes a considerable profit, but all this has to be paid for extra in purchasing the crude metal.

In consequence of the numerous circumstances which affect the cost, an approximately satisfactory estimate of the total amount of capital required to be invested in establishing an electrolyte refinery to deposit a given amount of copper daily can only be arrived at by means of a knowledge of all the essential particulars in the given case.

Recapitulation.—In establishing an electrolytic copper refinery, the chief points usually require to be settled in the following order: 1st. The amount of copper to be deposited per week. 2d. Amount of mechanical power required and the kind of motor. 3d. Degree of purity of the solution and of the crude metal. 4th. Rate of deposition per square foot of cathode surface per week. 5th. Total amount of cathode surface necessary. 6th. Total number of vats in series. 7th. Magnitude of each vat. 8th. Electromotive force and strength of current necessary. 9th. Kind of dynamo. 10th. Magnitude of the main conductors. There are, of course, other important points to be first considered, such as the most suitable locality for cheap motive power, cheap conveyance, etc., but those do not come within the intended scope of this article.

Street Railways.*

BY THEO. P. BAILEY.

The practical development of electrical street railways and their commercial perfection may properly be said to have been accomplished within two years, and yet there are at the present time 246 electrical street railway plants either in operation or ready to be put in operation within a short time. Two years ago, and even within the past twelve months, we were asked many questions by intending purchasers which to-day are not even hinted at. Some of the prevailing questions of that age were: Can electricity be applied in our case? Can a street railway, equipped with electricity, be made a practical and commercial success? What will be the life of the apparatus? What will it cost to keep the apparatus in repair? Is not the current dangerous to human life? Will it not ruin the watches of passengers?

The street railway people to-day appear to have become thoroughly satisfied on these questions, and consider it an idle waste of time to discuss them further. But in lieu thereof they ask us this: "How soon can you furnish the equipment for our road, and what will it cost?" Just think of this statement for a moment: Two hundred and forty-six electrical railways in operation, embracing 2,024 miles of track and 3,830 motor cars, requiring in the neighborhood of 6.400 motors, with a probable aggregate capacity of 174,435 h. p., employing an electrical generating capacity at the station of about 94,880 h. p. Did any one of you anticipate two years ago that such a condition of facts could under any circumstances be realized within so short a time? I attribute this wonderful development and success to the following causes:

First, the full practicability of the undertaking; second, the wonderful earning capacity of the electrically equipped car as compared with the horse car; third, a determination on the part of the electrical manufacturers to meet the requirements of the railway companies, and fourth, the untiring and indefatigable efforts of the exploiter or salesman.

Among the numerous and possibly fatal objections raised to the use of electricity, when it was proposed to apply it to street car propulsion, was that grades exceeding five per cent. could not be mounted. But experience and practice have shown that grades as high as 14 per cent. can be ascended with reasonable safety and satisfaction. There is a grade of 13.2 per cent. at one point on the line of the street railway at Lynn, Mass., over which 16-foot cars equipped with two 15 horse power motors are in daily and successful operation. At Milwaukee a grade of 10.3 per cent., 430 feet long, is encountered and successfully operated over or upon by 20-foot cars, equipped with two 15 horse power motors, the total weight of car complete with passengers being 10½ tons. A similar grade is met with at Newport, R. I., and Omaha, Neb., and numerous grades almost as heavy are seen in the electric railway systems at Des Moines and Davenport, Iowa, and Kansas City, Mo.

At the present time there are as nearly as can be ascertained 957 street railways in the United States and Canada. Of this number 589 are operated by horses, 49 by cable, 246 by electricity, and 73 by steam.

It is estimated that the total money value of these combined properties is $164,400,000, proportioned as follows: Horse railways, $58,900,000; cable railways, $49,000,000; electric railways, $49,200,000; steam railways, $7,300,000. These figures are at best only approximations, having found it impossible to secure absolute information.

This combination of motive powers is doing service over or upon 8,818 miles of track as follows: Horses, 5,713; cable, 527; electric, 2,024; steam, 554.

I find that the cost per car mile for the several methods referred to, including all operating expenses and fixed charges, other than interest, is as follows: Horses, 5.7 cents; cable, 2½ cents; electric, 2.2 cents; steam, 5 cents.

A large majority of the street cars equipped electrically at the present time are mounted upon a single truck, to which is attached one or two motors, as required by the conditions existing in each particular case. The lightest equipment with which I have had to do has been a single 15 h. p. motor upon one truck, and the heaviest equipment has been two 15 h. p. motors upon one truck. The tendency, however, at the present time seems to be in the direction of longer cars, double trucks, and heavier motors. This action is prompted very largely, no doubt, by the sad and costly experience of some companies where trailers were used in connection with the motor car; serious accidents, and, in some cases, death, having resulted from injuries sustained by passengers in falling between the motor and trail car while passing from one to the other.

The use of the longer car with double trucks is recommended further as a means of comfort to the passengers, and also on account of the longer life of the car and its equipments. This style of car is, of course, unattended by the oscillating motion found in the shorter car with a single truck. Where the shorter motor car is used with a trailer experience shows that there is a great loss in wear and tear by reason of the cars jamming together when the brakes are applied. This fault is obviated in the longer car, and while its seating capacity may not be equal to that of two shorter cars, it is approximately so. It is claimed further for the longer car with double trucks that less energy is required to operate it; also that it saves the expense of one man, decreases the expense of maintenance and increases the facility for handling passengers.

In treating of the subject of electric railways from a commercial standpoint I have considered only that branch designated as the single wire overhead system.

For obvious reasons too much care cannot be observed in the planning and locating of the various factors which go to make up a complete railway plant. Assuming that the railway company has secured the desired franchises and rights of way, and has laid out its lines of track so as to avoid all excessive grades, and yet reach the attractive and important points of the town or city, and that it has been fortunate enough to make proper selection of its apparatus, the next important work for it to determine is the location and arrangement of its power station. The selection of a site should be made with reference to obtaining the best facility for handling coal and obtaining water, and also with reference to the electrical centre of the railway system, in order to realize the highest degree of economy in the operation of the plant. The arrangement of the power station is equally as important as its location, with regard to handling the work with the least cost for labor. The selection of the steam plant is a matter of great importance, and should be left with a thoroughly competent and reliable engineer to determine what particular type of engine, boiler, etc., should be used; and the matter should be left under his direction and care until the installation has been completed. It is manifest that in so doing serious blunders will be avoided. I do not think it can be justly claimed that the railway companies have been too liberal in the amount of horse power purchased for the operation of their generators.

In order to secure the best results with reference to reliability of service, the horse power of the engine should be at least 20 per cent. greater than that of the generator which it drives, in order to provide for loss in transmission and excessive loads which are thrown on to the generator by reason of a large number of cars starting at the same time, or on account of a ground being accidentally thrown upon the line. The steam plant should be so arranged and connected to the generators that either engine or generator may be readily interchanged; and the arrangement of the engines made with reference to future extensions. The switchboard containing the indicating and regulating devices should be located so as to be most accessible to the attendant.

Both the power and electrical plant when complete and ready for operation should be placed in the hands of men of experience and learning in these departments, in order to insure reliability of service and the greatest economy in operation and maintenance. I would rather provide in advance for the expenditure of one thousand dollars or more in this department than to run any risk of having to pay out four times that amount in repairs and losses occasioned by mistakes of incompetent men.

The location and arrangement of the car house is a question of considerable importance, and open to serious mistakes growing out of bad location or improper interior arrangement. Some advantages are secured by locating the car house immediately adjacent to the power station. In this case it may be heated with the exhaust steam from the power plant, and the services of employés utilized in both buildings, and repairs to apparatus concentrated at one point. The car house should be provided with suitable pits for the inspection of the motors, and also have proper accommodations for cleaning the car bodies. If the car house is to accommodate more than 20 or 25 cars, it should be provided with running and turning tables, and should also have more than one exit.

I cannot pass from the question of inspection of apparatus without emphasizing the extraordinary importance of having this work done thoroughly by competent and faithful attendants. With electrical apparatus of standard makes we can reasonably expect that a motor car sent out in the morning for the work of the day, having passed through proper inspection, will perform its duty with a degree of certainty that need leave but little, if any, cause for anxiety. This feature is perhaps the most difficult one to impress upon the management of electrical railway companies, more especially where such railways have been converted from animal power. If railway companies will guarantee that degree of care and watchfulness in the operation of their motors indicated above we take practically no chances by giving them the broadest guarantees as to the durability of the apparatus and the cost of maintenance and repair.

It is apparent that in the overhead construction the highest degree of care should be exercised as to its details and arrangement, for this part of the equipment is constantly open to criticism. We cannot blind our eyes to the fact that serious, and in some instances fatal, criticism has been made to this work. We must all avail ourselves

* Read before the Chicago Electric Club, Nov. 17, 1890.

of the experience which has attended our efforts, and see to it that our overhead construction is not in any case, or for any reason, slighted.

I think an iron pole, 28 or 30 feet long, made in three sections of extra strong pipe six inches in diameter at the base, and four inches at the top, provided with wheel base and insulated cap, presents the most sightly appearance on the street and forms the most substantial construction that can be had. Next in reliability and appearance is an octagonal pole of Southern pine suitably painted; and lastly, and the pole most commonly used, the Western Union standard. These poles should be properly set with sufficient rake to allow of sustaining a strain of at least 900 pounds. To these poles should be attached by means of eye bolts a galvanized steel wire having a diameter of at least .204 of an inch and drawn taut so that the poles will come to a perpendicular position. To these span wires there should be attached a suitable insulating device over the centre of each track with proper attachments for suspending the trolley wire. This insulating device should be small in its construction, consistent with strength and high insulation, and the insulating material formed in such manner that it will in itself constitute a protection against moisture. The trolley wire should, in my judgment, be at least three-eighths of an inch in diameter, considering the objection that is raised to the multiplication of wires in the streets. This wire should be hard drawn copper, in lengths of at least one mile each. In this case the number of splices is reduced to a minimum, and by means of a suitable splicing ear the joints can be neatly, perfectly and securely made.

Where the streets are of a width of at least sixty feet from curb to curb it is regarded as thoroughly safe and practicable in cases of double track roads to place the poles in the centre of the street between the tracks, and whether those poles be made of iron or of wood of octagonal shape, I consider that this arrangement presents the best form of overhead construction that can be secured.

When a conduit can be constructed that will permit of the safe, reliable and economical operation of street railways by means of electricity we will all rejoice and be glad. If its first cost be made sufficiently reasonable to permit of its use in cities of, say, 50,000 inhabitants, it will be a magnificent achievement, and one that will surely bring its just reward to the successful inventor.

This thought is not prompted by reason of any vexatious troubles or annoyances which have occurred in the operation of the overhead system, but wholly on account of the objections which have been raised to the rapid multiplication of poles and wires in the streets, occasioned by the remarkable development and progress of the electrical science.

One of the prominent electrical companies is, and has been for some time, carrying on extensive and elaborate experiments with conduits, but has not, I believe, fully satisfied itself of the commercial success of its latest undertaking.

I find little or no objection to overhead wires in places of less than 50,000 inhabitants. For this reason and the fact of its low first cost the overhead system will no doubt continue to be used in such places for some time to come regardless of developments in the conduit system.

One of the most important features of an electric railway system is the track or roadbed. My experience has been that sufficient attention has not been given to that part of the equipment, especially until very recently. The track should be constructed of a good form of girder or "T" rail, weighing 54 or 40 pounds per yard respectively, and should be attached securely to suitable ties placed not more than two and one-half feet apart. It should be well ballasted, and where crossings are made over other tracks solid castings should be used in order to prevent the jolting and jarring which occurs when passing over them. The rails should be kept as clean as possible where they are used as part of the return circuit. In order to use the rails of the track in completing the return circuit they should be firmly connected together by a copper wire, in addition to the ordinary fish-plates, and in certain cases depending wholly upon the length of the line, number and extent of grades, and number of cars and amount of traffic, there should be used a supplementary copper wire, the size of which must depend on the conditions just named. It is asserted by some electricians that the efficiency of the return circuit is increased in all cases by the use of a supplementary wire; but my experience has been that, upon small roads where the grades and traffic are light, satisfactory and economical operation is secured where the supplementary wire is omitted.

Some of the essential requisites of an electric motor car are proper controlling mechanism and reversing switch for controlling the speed and direction of the car, a lightning arrester and multiple fuse-box. It should also be provided with suitable life-guards, gong bells and headlights. The wheels of the car should in my judgment be at least 33 inches in diameter and weigh 300 pounds each. This will give increased adhesion and allow the motors to be raised sufficiently high from the ground to practically prevent the possibility of being injured by striking obstacles between the rails.

Increased speed with a very light increase of power will result by the use of the 33-inch, instead of the 30-inch, wheel. The possible speed of a car equipped electrically is measured only by the limit of safety. The regulation speed in the majority of places is twelve miles per hour and the average mileage per car per day about 115. It is well known that upon well regulated steam railroads the locomotives rarely make a continuous run of over 100 miles per day; and, considering the extraordinary care that is given to them, and remembering in the same connection the very slight degree of care given to the average electric street railway motor, I think the latter is entitled to a very handsome compliment for the good service it gives us; and when you know that the best average mileage that can be made by a car propelled by the Kentucky horse or Texas mule is sixty miles per day, and even in doing this it is necessary to make at least four changes per day, I think you will admit that the electric railway motor is doing most admirable service.

The smallest town in the United States which has an electric street railway in operation is Southington, Conn., with a population of 5,400. The cars are in service over two miles of track, and the average daily receipts are $9 per car. The power for the operation of this road is furnished by the local lighting company, and costs $1.25 per car per day. The largest electric railway is at Boston, Mass. This entire system comprises 284 miles of track, sixty of which are electrically equipped, and there are 312 motor cars in operation. During the month of August they had 300 motor cars in service, making a total mileage of 384,700,000. The mileage of the tow cars was 59,948,000, making a total car mileage of 444,648,000. From Aug. 10 to Aug. 16, 700,000 passengers were carried by these cars without a single delay. In the month of September 312 motor cars were in operation, making a mileage of 343,466,000, and the mileage of tow cars 56,047,000, making a total car mileage of 399,513,000.

Average number of motor cars run per day	20
Average number of trail cars run per day	0
Average number of hours per car in service per day	18
Average number of miles per car per day	108
Electromotive force	500
Average ampère readings taken hourly	122
Average electrical horse power	81.8
Average electrical horse power per car	4.9
Number of passengers carried per day	11,060
Number of passengers carried per car per day	553
Cost of operating, per car mile	$0.0616
Receipts, per car mile	.2560
Cost of operating, per car per day	6.65
Receipts, per car per day	27.65

Most flattering testimonials have been received from railway companies who have adopted the electric system, and while they express their absolute satisfaction with the new motive power, they also state that the earning capacity of their roads has been materially increased. In some cases the increase is given as high as 400 per cent., and in others as low as 50 per cent.; but in no case that I can now remember has the increase been given lower than the amount last stated.

Inquiry is sometimes made as to whether a motor car can be safely and reliably operated without a conductor. The present form of trolley and overhead construction readily permits of this; but I do not regard it as practicable or advisable except in the smaller places where the business of the road will not justify the expense of a conductor. I am familiar, however, with a number of roads in towns or cities having a population of less than 30,000 where the car is in the exclusive charge of the driver, and no trouble is experienced in its operation. With a good track there is little, if any, possibility of accident when proper care is exercised in taking curves and switches. Where the business will warrant the expense, however, there should be a conductor with every car or train.

We cannot overlook the fact that there are still some complaints of excessive cost for repairs and maintenance of the electrical apparatus, but I insist that the responsibility for this condition does not rest altogether with its manufacturers. The managers of these electric roads must appreciate that they are exacting a greater mileage duty of their motors than is expected of the ordinary railroad steam engine and under conditions manifestly more unfavorable. If they will admit this, and see to it that their tracks are put in good order and so maintained, and the same degree of care and attention given to their motors that is given to the steam engine, I am satisfied they will have little to complain of. How rarely do you find an electric motor operated on a track like that prepared for the steam engine! And how seldom do you find a man in charge of the motor car who has the intelligence, training and experience of the steam engineer!

Several railway companies which adopted the cable system before the possibilities of the electric system were fully appreciated or understood are now seriously considering the complete displacement of that system and the substitution of electricity in its stead. I was recently informed by the president of one of the electric railway companies whose line is a competitor to a cable road that the latter company, feeling keenly the effect of the competition of the electric system, had about concluded to reduce the fare on their road to four cents per passenger. Before this action takes place, however, I have no doubt that some bright representative of the electric system will persuade our cable friend to join the procession of progress, abandon the cable, welcome and adopt electricity as the motive power, and thus preserve the independence and stability of his street railway system.

There is no system or method of rapid street transportation that is so universally popular as the electric system; its wonderful flexibility is unparalleled in the history of street railways; capable of moving in either direction with equal facility, its value is materially enhanced from the standpoint of safety. Its first cost is about the same as for the animal system and considerably less than the cable system. Knowing what the possibilities of the electric system are, and how cheaply it can be maintained and operated under proper conditions, I think we will see street railways thus equipped in many towns of a population not exceeding 10,000, and in some cases even less, and at a period not very remote.

I have previously alluded to the remarkable growth of the electric railway business, and given some reasons for it, but I do not feel that full justice has been done to the pioneers—I mean the manufacturers of the apparatus. When you consider what they had to do, and what they did do in order to inspire confidence in the undertaking, I think you will all agree with me that they have merited even greater success than has attended their efforts, if that be possible. Contracts with all sorts of guarantees were made, long trial periods were given, the cost of maintenance guaranteed to be less than for the same number of cars operated by animal power, the current guaranteed not to be fatal to human life, and the system warranted to work in a thoroughly practical and successful manner, with a general and sweeping provision that in case of failure in any of the guarantees the railway company could, at its option, throw the apparatus out and assess the electrical company any damages which it had sustained by reason of the alleged experiment. Was there ever a new industry vouched for so absolutely by its projectors? Had the electric companies been less liberal with their guarantees, and not exhibited such a marked degree of confidence themselves, we undoubtedly would have been able to-day to count the number of electric railways by tens instead of by hundreds, for it is but a short time since the financial world has given its unqualified endorsement to the system. Bankers and trust companies took no part in formulating public sentiment or confidence in this matter. The undivided burden was assumed and borne by the electrical companies, and not until they had fulfilled their numerous guarantees faithfully and well, and demonstrated beyond all peradventure the full and complete success of the electric street railway was the moneyed man or corporation willing to assume any hazard or risk. How the conditions have changed in two short years. Every principal city in the United States has now its electric street railway, full confidence has been established, and unreasonable guarantees are no longer required.

In closing, permit me to offer this prediction, that within a few years surface and elevated railways operated by animal, cable or steam power will be numbered with the events of the past, and electricity, with all its beautiful attributes, in all its grandeur and magnificence and in the full measure of the wide range of its possibility, will claim supremacy in the broad realm of street railway transportation.

Special Correspondence.

NEW YORK NOTES.

Office of The Electrical World,
167-177 Times Building, New York, Nov. 17, 1890.

Has Opened a New York Office.—The Eddy Electric Manufacturing Company has opened an office at 15 Cortlandt street, this city, which will be in charge of Mr. Walter C. McIntire.

Mr. G. D. Fisher, of the American Leather Link Belt Company, 72 Cliff street, this city, has just returned from Rochester, N. Y., with an order for two 18 inch belts, each 50 feet long, for the Edison Illuminating Company, of Rochester.

The Elektron Manufacturing Company, of Brooklyn, has secured an excellent lot of agents for the sale of the Ferret electric motors and dynamos. Mr. C. M. Barclay, who has the agency of these machines for Chicago and several of the Western States will be remembered as the former manager of the territory of the stationary motor department of the Sprague Electric Railway and Motor Company.

Summit, N. J.—The streets of Summit are soon to be lighted by electricity A three-years' contract has been awarded to J. J. Wohltman, contractor, 115 Broadway, N. Y. It is contemplated to erect a 1,500-light plant, and work will probably be commenced by Dec. 1. Mr. Wohltman was formerly with the Westinghouse Company, and will make a worthy member of the fraternity of contractors and electrical engineers. He is one of the pioneer telephone men who went over to Europe in 1879 in behalf of the Edison interests. Mr. Wohltman's prospects in the lighting and railway field are excellent.

Mr. Charles L. Eidlitz of this city is installing an electric light and power plant at the Brooklyn Bridge for 500 lamps of 16 c. p. each, together with three motors of 3 h. p. each. Edison dynamos will be used and the plant will be a model one in all respects. The premises will be occupied by a firm of wine merchants and the electric plant will include pumps operated by electricity for the transferring of wine from the large tanks to the casks. A large engine house is to be built especially for the electric plant. Mr. Eidlitz is also just finishing the plant at the Museum of Natural History in this city, which has capacity for 1,800 lamps of 16 c. p. each of the Edison system. Among other installations made by Mr. Eidlitz may be mentioned the Masonic Temple, corner 23d street and 6th avenue; for 1,000 lights for the Manhattan Electric Light company; the new Democratic club building on 5th avenue in this city, and the quarters of the American Book company at 806 Broadway for 400 lights.

Lecture at the New York Electric Club.—The secretary of the club has sent out a notice which reads as follows: "The regular monthly meeting of the Electric Club will be held at the club house, 17 East Twenty-second street, Thursday evening, Nov. 20. The address of the evening will be delivered by Prof. E. L. Nichols, of Cornell University, beginning at 8 o'clock. The topic presented by the lecturer will be 'The Artificial Light of the Future,' and his plan is to point out the nature of certain limitations which seem to preclude hope of any very marked improvement in the efficiency of our present methods of lighting; then to discuss the properties of certain sources of light, not made use of at present, with a view to the more or less remote possibility of their development as practical illuminants. The lecture will include the presentation of some original work not yet published, together with the collation of various researches, which have not attracted general attention, taken singly, but which seem to Professor Nichols to be significant. The results will be presented by aid of lantern slides. Members intending to be present for dinner, should notify the clerk of the club house in advance." The secretary informs us that a table d'hote dinner will be served in the café down stairs at the club house to cost only one dollar per plate. W. T. H.

NEW ENGLAND NOTES.

Branch Office of The Electrical World,
Room 8, Cook Building, cor. Franklin and Congress Sts.
Boston, Nov. 15, 1890.

Bridgeport, Conn.—It is reported that the Thomson-Houston electric railway system is to be adopted by the Bridgeport horse railroad company.

The Thomson-Houston Motor Company has installed an electric hoist at the dock of the M. & M. T. Company, this city, for unloading vessels.

The Standard Electric Company, of Vermont, has installed a 500-volt dynamo at the works of the Oreman Wheel Company, Chicopee Falls, Mass.

W. S. Hill has just sold to the Cambridge High School a small experimental half h. p. dynamo to run a 18 h. p. motor for use in explaining electrical subjects in the school.

Nine Months' Sales.—The Thomson-Houston Electric Company is said to be preparing a statement of sales, etc., for the nine months ending Nov. 1, 1890, and will soon issue the same with comparisons.

The Ashton Valve Company, of Boston, has sued the Coule & Muffler Safety Valve Company, of Baltimore, for infringement and the evidence is now being taken. The Ashton people have a strong case and feel very confident of success.

No Electric Cars in Danvers.—At an adjourned town meeting this week at Danvers, Mass., to act on the petition of the Naumkeag Street Railway for leave to extend its overhead electric system through that town, permission was refused, 384 to 121.

Boston, Mass.—At a meeting of the Board of Aldermen, Monday evening, the ordinance concerning electric wires and creating the office of city electrician was passed. This ordinance was printed in full in the last issue of The Electrical World, and had already been passed by the common council.

Amesbury, Mass.—The electric light company has just put in a new 200 h. p. engine, which will more than double its present motive power. A new incandescent machine of 500 lights will also be put in. The electric cars of the Newburyport & Amesbury Railroad are now supplied with power, as well as several factories in the vicinity.

Mr. H. C. Whitney, superintendent of agencies for the Consolidated Electric Storage Company, of New York, was in Massachusetts last week. He reports the company as doing a big business, and has established agencies as follows: Fall River, Mass., Wm. E. Tanner; Providence, R. I., Providence Construction Company. He will shortly announce the Boston agency.

Important Suit.—In the Supreme Judicial Court of Massachusetts, on Nov. 13, two separate cases of the Suburban Light and Power Company, petitioner for mandamus, vs. the Boston Board of Aldermen, were argued, seeking to compel the city to locate places where plaintiff may erect poles on which to attach wires, so that it can complete an alleged contract it has with the city to supply electric lights.

Municipal Lighting in the Courts.—The application for an injunction to restrain the town of Peabody, Mass., from appropriating money to erect an electric light plant came up for a hearing in the Supreme Judicial Court of Massachusetts last week. The petitioners set forth that there were two questions presented on this report: (1) Whether a town may without special legislative authority incur a large expenditure for the erection and maintenance of an electric light plant for lighting its streets; and, (2) Whether, if the town may lawfully do this, it may incur a larger expenditure than would be necessary for such purposes, with the view of selling electric light for commercial purposes not only to its own citizens but to the public generally. The town argued that it has the right to light its streets on three grounds: (1) By express statute provision, and the fair, reasonable and necessary implication thereof. (2) By usage which has placed street lighting among the subjects of common interest embraced in the "prudentials" and "other necessary expenses." (3) As incidental to the exercise and enjoyment of other powers, and the discharge of other duties undoubtedly possessed by and imposed upon towns. The court reserved its decision. L. H. H.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
31 CITY BUILDING, PHILADELPHIA, Nov. 15, 1890.

The Curwensville, Pa., Light and Power Company has been incorporated with a capital of $16,000.

J. H. Lehman & Co., manufacturers of electrical appliances, have moved from 51 to 38 South Fourth street.

L. F. Seyfert's Sons have placed a 40 h. p. Southwark engine and boiler at the Manual Training School for operating the electric light plant.

The National Electric Company is wiring the fine residence, barn and tenant house of Mr. Eugene Delano, of Bryn Mawr, for incandescent lights.

Mr. H. B. Cutter has purchased the electrical construction business of Messrs. Vallee Bros. & Co. The latter will devote their entire attention to their electrical supply department.

Notice of Removal.—After the 25th inst. the office and works of the Moore and White Company will be at the Northeast corner of 15th street and Lehigh avenue, on the Philadelphia & Reading Railroad, instead of at 1312 Buttonwood street, Philadelphia.

Messrs. Wright & Starr, who have recently gone into partnership, have been well known in connection with the Edison Electric Light Company in this city, both gentlemen growing up, as it were, with the station. Mr. Starr, before his connection with the above company, was in charge of the Edison station at Chester, Pa., where he did excellent service from the starting of the station to the commencement of the Philadelphia station. Both Mr. Wright and Mr. Starr have had wide experience in all kinds of electrical work, both in construction and testing, the excellent service of the Edison feeders going out Ninth street from the station and up and down Market bearing evidence of the careful work of these experts. They have established themselves at 37 South Third street, as contracting and consulting engineers, and will contract for isolated, central station or railway work. They also make a specialty of calibration of instruments. Owing to the well known ability of both gentlemen, they already have several large plants under consideration, both in this city and elsewhere.

Recent Installations.—The Philadelphia office of the Westinghouse Electric and Manufacturing Company is now installing the following plants: Norfolk & Western Railway Company's Tug No. 2, about completed, is an exact duplicate of the Tug No. 1, described in THE ELECTRICAL WORLD of Oct. 11; Wm. Cramp & Sons Ship and Engine Building Company, 300-light incandescent plant for lighting the offices; J. B. Mawson, Yardley, Pa., 50-light plant; Wilmington Wheel Company, Wilmington, Del., 50-light incandescent plant; McDowell Paper Mills, Manayunk, Pa., 50-light incandescent plant, with Westinghouse engine; East Lake Woolen Company, Bridgeton, New Jersey, increase of 100 incandescent lights and Westinghouse engine; E. C. Knight & Co.'s sugar refinery, increase of 100 incandescent lights; Allison Manufacturing Company, Philadelphia, 200-light incandescent plant, with Westinghouse engine, and for the Baldwin Locomotive Works. As this is the first alternating current arc light plant that has been started at the Baldwin Locomotive Works, Philadelphia, it is an object of great interest. W. F. H.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, Nov. 15, 1890.

The Woodland Electric Company has been incorporated at Cleveland, O., with a capital stock of $30,000.

The Mutual District Messenger Company, Chicago, has been incorporated with a capital stock of $50,000; incorporators, H. A. Douglas, G. W. Conover and William Taylor.

The Badger Illuminating Company, of Milwaukee, Wis., has accepted the terms of the city and taken the contract for electric lighting for the next year at the rate of $112.50 per lamp.

The Greenville Electric Light and Power Company has been incorporated at Greenville, Ill., with a capital stock of $10,000; incorporators, C. D. Hoiles, W. V. Weise, and others.

Racine, Wis.—Local capitalists have filed articles of incorporation for the People's Street Car Company, with F. K. Bull, B. B. Blake and W. P. Dutton as incorporators. The capital stock is $150,000. The new line will be run by electricity.

The Avoca Electric Light and Power Company, at Council Bluffs, Ia., has been incorporated with a capital of $10,000; directors, H. O. Seiffert, G. Dietrich, Fremont Benjamin, J. H. Jenks, N. D. Sanford, Charles N. Voss, J. J. Hepsley.

Motors in a Newspaper Office.—The Chicago *Inter-Ocean* evidently appreciates good service, as it has added two more 15 h. p. Mayo motors for driving the presses. This makes four 15 h. p. and one 10 h. p. Mayo motor that it has now in service.

The Walsh Gasoline Torch Manufacturing Company, Chicago, has elected the following officers; E. J. Hauley, President, and J. C. Walsh, Secretary and Treasurer. O. Johnson, of Chicago and Charles McFadden, of Philadelphia, were elected directors.

Extensive Motor Plant.—It is rumored that Mr. Victor Lawson is considering the advisability of installing an electric motor plant having a capacity of 500 h. p., one-half of which will be a duplicate plant held in reserve, to drive the machinery required in preparing the Chicago *Daily News*.

The Illinois Electrical Material Company, Chicago, is making a specialty of electric railway material, and will soon have a very complete catalogue ready for mailing, the classification and arrangement of which will be on a plan somewhat novel and far simpler than many of the catalogues now in use. The intention is to make it a ready reference book of sufficient value to be kept constantly at hand where it can be consulted when supplies are needed.

The Western Power Construction Company, Chicago, has secured the contract for the installation of the steam plant at Seattle, Wash., for the West Street & North End Railway Company, consisting of two 200 h. p. Corliss engines and a battery of boilers having a capacity of 400 h. p. This company will also install the steam plant for the Tacoma & Steilacom street railway and for the Centralia (Wash.) Electric Light and Power Company.

The Auditorium Organ.—THE ELECTRICAL WORLD of Feb. 1 contained a full description of this grand instrument, which was formally dedicated on Oct. 29, its 7,200 pipes and registers being operated or controlled with the aid of electric motor service. The necessary cables and conductors used in connection therewith were furnished by the Bishop Gutta Percha Company, of New York, through its Western agents, the Illinois Electrical Material Company, of Chicago.

St. Louis, Mo.—A peculiar accident, showing the power of the electric motor, occurred recently in St. Louis, at the car house of the Lindell Railway Company. Some workmen, engaged in adjusting the motor and connections of a car standing on the track just inside the car house, had thrown out all the resistance, and left the trolley on the wire, it being early in the morning, when no current was running. Suddenly the current was thrown on the system, and the car shot forward, crashed through the heavy doors of the car house, and went nearly across the street, partly wrecking the car and completely demolishing the doors of the barn, which were over eight feet wide and fifteen feet high.

Telephone Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone stocks as follows:

Chicago	$298@$300	Cumberland	$ 59@ $60
Central Union	58@ 59	Wisconsin	118@ 120
Michigan	92@ 95	Bell of Missouri	155@ 160
Great Southern	32@ 35	Iowa Union	20@ 21
Colorado	38@ 40	Missouri and Kansas	55@ 57
Rocky Mountain Bell	40@ 45		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$93@$ 96	Chicago Edison Co	$130@$132

CINCINNATI, O., Nov. 15, 1890.

Insane Asylum Plant.—The trustees of Longview Insane Asylum, at Carthage, have recommended the erection of an electric light plant, its cost not to exceed $7,500.

A New Dynamo.—The Cincinnati Panel and Wood Working Company has installed a new Thomson-Houston dynamo of that company's motor type, having a capacity for 100 lights.

The First Electric Elevator in Cincinnati is now running at the Reid Building, 177 West Fourth street, and is attracting considerable attention. The elevator is operated by a 15 h. p. motor of the Thomson-Houston type, and is run at a speed of 200 feet per minute. The Evans friction apparatus is used and the whole machine occupies but a very small space.

Placing Wires Underground.—The Queen City Electric Light Company has petitioned the Probate Court of Hamilton County, O., for authority to lay conduits under the streets of Cincinnati for the purpose of carrying electric wires through them. The company avers that its business has so increased that it is impossible to meet its requirements except by the underground system. Public sentiment has turned sharply against overhead wires, and the lately defunct Board of Public Improvements had begun to refuse a number of service connections on prominent streets. Just now the Edison General Electric Company is the only concern having a conduit or the right to construct one. This right was granted by the Probate Court. Some weeks ago the city solicitor filed an appeal in the Common Pleas Court from this judgment granting the franchise. It is claimed by the company that the appeal cannot be entertained for the reason that it was not filed within the time prescribed by the law, which is six months.

Electric Road versus Telephone Again.—Judge Hunt, of the Superior Court, of Cincinnati, heard on Wednesday a motion for the modification of the order of Judge Taft, enjoining the use of the single trolley system on the Carthage extension of the Mt. Auburn electric road. The case occasioned a bitter fight between the Mt. Auburn Street Car Company and the Telephone company, the latter attempting to prove that the electricity of the electric road rendered the telephone wires to the suburbs useless. Carthage is a village situated some seven or eight miles from the centre of Cincinnati, and has numerous telephone connections both in factories and the homes of business men doing business in Cincinnati. The line has been established to Carthage for several years, and the company claimed it had the priority of right of way. Despite Judge Taft's decision against the electric road the company has gone on laying its tracks and erecting the poles. The road is now about complete. The telephone company resisted the motion for a modification of Judge Taft's order strenuously. The case was taken under advisement. F, DE L.

ENGLISH NOTES.

(*From our own Correspondent.*)

LONDON, Nov. 6, 1890.

Subways for Supply Mains.—A memorial is to be presented by the London vestries to the London County Council urging it to bring forward a bill this session dealing with the question of subways for general supply purposes.

New Castle-on-Tyne.—The good inhabitants of New Castle were alarmed last week by a small explosion in the conduits of the electric light company of that town, which resulted in the blowing off of the lid of a junction box and the injury of five or six people. Fortunately nobody was seriously injured. As usual gas leakage is supposed to have been the cause of the mishap.

Heavy Telegraph Work.—The interest in some recent political demonstrations at New Castle was shown by the heavy call made by the press upon the telegraphic resources of that town. No less than 17 special Wheatstone circuits were arranged for the occasion and the total number of words signaled during three days' speech-making was in round numbers 300,000.

Municipal Lighting.—This afternoon the foundation stone of the 10,000-light central station of the St. Pancras Vestry was laid. According to the first plans of Prof. Henry Robinson the distribution was to have been carried out by continuous current transformers, but judging from the information furnished by that gentleman at the ceremony this afternoon, this plan has been abandoned, and distribution will be carried out on the three-wire system, with secondary batteries to supply current during the hours of light load. There will be nine incandescent light dynamos and two arc light dynamos, the vestry having decided, as soon as the station commences working, to employ 90 10-ampère lamps for street lighting. The distributing mains have been designed to have at the outset a current-carrying capacity sufficient for 25,000 16 c. p. lamps, burning simultaneously. It is proposed to lay five miles immediately. The storage battery will have a capacity of about a thousand ampère hours. The foundation stone of the Brighton Municipal station was also laid yesterday afternoon.

The Westminster Electric Supply Corporations.—Since the acceptance, six months ago, by Prof. A. B. W. Kennedy of the post of engineer to this company the work of erecting generating stations and laying mains has proceeded apace. The district allotted to the Westminster Company has an area of about 2 square miles, and comprises the well-known residential quarters of Belgravia and Mayfair; it is bounded on the south by the Thames and on the north by Oxford street. At the present moment three generating stations are in course of erection, and an extensive and reliable supply may be expected to be provided within the next few months. The mains are already laid in about 10 miles of streets, and the work is being actively pushed on. In one portion of the district the Crompton system is being employed, while in the other Professor Kennedy is laying copper strip conductors resting on glass or porcelain insulators fixed in the floor of concrete culverts, the conductors not being chained up, as in the Crompton system. The supply will be on the plain two-wire system with storage batteries (Crompton-Howell) as a reserve, and all the three stations will be connected together. In a small corner of the area allotted to it the Westminster Company is without a competitor, but at most points it is in competition with the London Electric Supply Corporation. The company has actually at work a small station supplying current to the House of Commons and some residences in the vicinity, but it is anticipated that by the end of the year this temporary installation will be shut down. A remarkable feature of this company's system is the great variety of its plant. Thus at one or the other of the three stations there will be Babcock & Wilcox or Davey-Paxman boilers, Willan or Paxman engines, Goolden, Crompton, Siemens, Elwell-Parker or Edison-Hopkinson dynamos. The total output of the three stations when finished will be about 2,500 h. p.

News of the Week.

THE TELEGRAPH.

Mr. Jabez Fearey, a well-known old time telegrapher, of Newark, N. J., died on Sunday morning at the age of 52. Mr. Fearey was born in England but came to this country when a child. He lost an arm in the war. For many years he held the position of manager of the Western Union office in Newark, but a few months ago became manager of the Postal Company's office in that city. He leaves a wife and four children.

Mr. Edison, in an interview a day or two ago, was asked whether he thought the present style of telegraphy would soon be done away with. His reply was: "Yes, but not until the old timers have disappeared. The operators now have a deep seated prejudice against any inventions that will simplify telegraphy. But some of the inventions have already been made, and it is only a question of time when a man can rush into a telegraph office, scratch off a note to his wife in Chicago and the exact duplicate of his note will be delivered over the wire to his wife. This will not be all by any means, but maps, pictures (newspaper pictures) will be transmitted promptly by wire. These new inventions will be for the coming generation to see in practical use. The old stagers will fight, of course, to keep the new order of things from coming rapidly into practical use, because it will interfere with their occupation."

THE TELEPHONE.

Increase in Subscribers.—The Arkansas division of the Erie Telephone Company gained 25 subscribers in October, the North Texas division 28. The Cleveland division lost two.

Telephony Through Telegraph Cables.—The Black & Rosebrugh telephone system has been in successful operation on the telegraph cable between Detroit, Mich., and Windsor, Can., for over three years. A "buzzer" is used and the call is received in the receiving telephone.

Duplex Telephony.—Dr. A. M. Rosebrugh, of Toronto, has just scored another victory in the United States patent office in duplex telephony. In an interference case of over three years' standing between Rosebrugh and Barrett, priority of invention has just been rendered in favor of Rosebrugh. In a former case between Rosebrugh and Carty the decision was also in favor of Rosebrugh.

Mr. David B. Parker, general manager of the Metropolitan Telephone and Telegraph Company, of this city, is sending out to subscribers a very cordial invitation to visit the central exchange at 18 Cortlandt street. The invitation reads as follows: "You are cordially invited to visit, at your convenience, our exchange at 18 Cortlandt street. We think you would be interested in witnessing the practical working of the telephone system in our operating room, where the largest and most expensive switchboard ever constructed is in use, and we believe the visit would result in mutual advantage in our relations. An exchange of suggestions as to use of the telephone, between officials of the company who are devoted to the subject in hand and subscribers who are relying upon the telephone system as an important business necessity or social convenience, may contribute toward improvement in service."

THE ELECTRIC LIGHT.

Dividend.—The Brush Electric Light Company, of Baltimore, Md., has declared a semi-annual dividend of three per cent. on its preferred stock.

Louisville, Ky.—The Louisville Electric Light Company, of which Mr. Sidney Sprout is the electrician and superintendent, is increasing its electric light and railway plants by the addition of several miles of line work, and is also building a new station. The Thomson-Houston system will be used.

Rates for Electric Lights.—We have received the following schedule of prices charged for electric light service by the Tampa Electrical Light Company: 16 c. p. light, 3c. after 10 o'clock ½c. extra per hour; 20 c. p. light, 4c., after 10 o'clock ½c. extra hour; 32

c. p. light, 6c., after 10 o'clock 1c. extra per hour; 45 c. p. light, 9c., after 10 o'clock 1½c. extra per hour; 60 c. p. light, 12c., after 10 o'clock 2c. extra per hour; 100 c. p. light, 20c., after 10 o'clock 3½c. extra per hour. Lights burning later than 10 o'clock must be paid for extra according to above schedule.

New Isolated Plants.—The western isolated lighting department of the Thomson-Houston Electric Company has closed a contract with the Atlantic Mining Company, of Houghton, Mich., for a nine-light arc plant. H. H. Shufeldt & Co. have, for some years past, been using electric lights at their distillery, 23 Larabee street, Chicago, having for the purpose a dynamo capable of supplying about 125 lights. Finding that additional lights could be used to good advantage, they recently asked for bids on a much larger plant, and the order has been placed with the western isolated lighting department of the Thomson-Houston Electric Company for a 400-light incandescent plant. The dynamo previously used will be discarded and an entirely new plant installed.

Financial Statement.—The Ft. Wayne Electric Company has declared a dividend of 75 cents per share of $25 for the half year, payable Nov. 15. Treasurer R. T. McDonald reports for the six months ended Aug. 31, 1890, sales, less commission, of $867,514, an increase of $107,205 over the previous six months. The net earnings are given as $161,206. Deduct the dividend of $90,000 May 15, and the balance is $71,206. Add the surplus of $172,334 March 1, and the total surplus Aug. 31 stands at $243,540. The capital stock is $4,000,000 and the half year's net income equals a plump four per cent. on this amount. The face value of the assets has been cut down rising $300,000, in the interest of conservatism, local company stocks being put in at 40 per cent., and bonds at 80 per cent., and a discount made on notes receivable and open accounts. The number of local companies using the Fort Wayne system was increased 24 in six months, or to 128. The manufacture of dynamos and lamps for arc lighting is to be carried on at Fort Wayne, instead of Brooklyn, and considerable economy is expected to result.

Electricity in the United States Navy.—Commodore George Dewey, Chief of the Bureau of Equipment, in his annual report to the Secretary of the Navy, says: "The lighting of ships of war by electricity, which was inaugurated by this government, has now become so essential that no war ship is considered complete which is not so lighted. During the year substantial progress has been made in the development and advancement of the system, which is being employed in the new ships, and progress abroad has been critically noted. Electric lighting plants have been installed on board seven vessels, and the work of installation is actively progressing upon four others. Special attention has been given during the year to the subject of means of interior communication on shipboard, and a telephone system is soon to be added experimentally to other devices in use on board one of the new cruisers. Night signaling by electricity has also been and is still actively under consideration, and it is believed that a system will have been devised in the near future which will meet the increasing necessity of the service in this respect. The great importance of an adequate method of communication at night between ships of a squadron or fleet makes necessary the utmost care in the consideration of the subject."

APPLICATIONS OF POWER.

The Union Electric Railway Company, at Helena, Mont., has been incorporated with a capital of $500,000; incorporators, Newton McConnell, Albert M. Thornburg, Edgar C. Richards, George B. Hopkins and John B. Clayberg.

The Northwestern Electric Motor Company has been incorporated at Chicago to manufacture and use electric motors and to sell and operate the same; capital stock, $1,000,000; incorporators, Thomas B. Bryan, Frank Weeks and M. W. Towle.

West Brooklyn Electric.—This company has been incorporated to build an electric railway five miles long at West Brooklyn, N. Y. The directors are: Richard Hawley, Charles Bellews, Jr., Allen N. Spence and John S. Kennedy, of West Brooklyn; Herbert N. Curtis and Henry C. Radford, of New York, and Thomas G. Spence, Andrew D. Baird, Joseph P. Puels, William P. Rae, William Wish and John Morris, of Brooklyn.

Electric Cars for the Beaver Railway.—The Central Electric Railway Company, of Beaver Falls, Pa., has been granted a charter and has also obtained permission of the boroughs of Beaver Falls, New Brighton, Bridgewater and Beaver to construct and operate the electric railway through the main streets of said boroughs. Work will be commenced on this road as soon as the weather permits. J. C. Whitla is the president and A. R. Leyda, secretary. The capital is $60,000.

Uniontown, Pa.—The Uniontown (Pa.) Street Railway Company has contracted for the laying of the track with the A. C. Townsend Railway Building Company, of Pittsburgh. The route for which the contract has been let is along Main and Fayette streets, making a complete circuit of these thoroughfares. The track for the Main street portion is to be completed by the 15th of December next. It will be laid in the centre of the streets, and will be of wagon tread width. The cars are to be propelled and lighted by electricity. The trolley wires are to be 20 feet above the street, and the poles, which are of wood, are to be attractively painted. Three cars are to be put on the route first, and will run from three to five minutes apart. The cars are to be vestibuled, and will be equipped with all the latest conveniences. The contract for the electrical equipments has been given to the Edison Company, of New York. The cars are to be built by the Brill Company, of Philadelphia. The Johnson girder rail of the best quality will be laid on sawed white oak ties, which will be laid beneath the surface of the street. The length of the line under contract is about one and three-quarter miles. The entire plant will cost $50,000. The dynamos to be put in will furnish sufficient power to run six cars when necessary. The company expects to have the Main street portion of the road completed and the cars running by Jan. 1. While the company expects to build branches to the surrounding towns, it has not as yet located or decided on any particular route or branch.

PERSONALS.

Mr. John I. Sabin, of San Francisco, Cal., was one of New York's visitors last week.

Professor Puffer, of the Massachusetts Institute of Technology, gave a lecture on electricity in Dexter Hall, Boston, one evening last week.

Mr. Will Phelps, formerly with an electrical company at Peoria, Ill., is now traveling in the Western States for the Brush Electric Company.

Mr. A. C. Durborow, the business manager of the *Western Electrician*, had a very handsome majority in his recent election to Congress. The official count gave him a lead of 3,101 in a district which gave nearly 2,400 majority two years ago to the candidate who was Mr. Durborow's opponent on Nov. 4.

Prof. Elihu Thomson, at the first monthly dinner of the Boston Electric Club this season, repeated some of his interesting experiments which exhibit the properties of alternating current induction.

Mr. Samuel Hoyt, one of the oldest telegraph operators in the country, and said to be the third who learned to take telegraph messages by sound, has resigned his position as general manager of the Western Union at Clinton, Ia.

Mr. Frederick B. Rouquette, for some time connected with the Edison works at Schnectady, left on Saturday last for Denver, Colo., to take a position in the district office of the Edison General Electric Company, in that city.

T. Reeve Rosebrugh, son of Dr. Rosebrugh, of Toronto, has been appointed demonstrator in mechanical engineering in the Toronto School of Practical Science. It is understood that he will probably be placed at the head of the department of electrical engineering soon to be established in connection with the science school.

Mr. J. E. Zeublin, formerly general superintendent in Chicago of the Baltimore & Ohio Telegraph Company and now assistant general superintendent of the Central Telephone Company of Ohio, with headquarters at Columbus, has been called to Chicago to relieve General Superintendent Beach, of the same company, who has been granted leave of absence for several months.

Dr. G. H. Kirwan, general manager of the Kirwan Electric Indicator Company, of Scranton, Pa., who has devoted some years to the perfection of electrical station and street indicators, and who has obtained several patents on instruments of this class, is in Washington securing patent office data for the preparation of a brief history of machines of this class, to appear in the new catalogue of the Kirwan Electrical Indicator Company.

MISCELLANEOUS NOTES.

The Redstone Electrical Company, of Uniontown, Pa. has added to its business that of electro-plating, and has already secured the material from Thos. Hall, of Boston, Mass. This company makes a specialty of mine signaling apparatus and general house furnishings in the way of electric annunciators, bells, burglar-alarms, etc.

Discovery vs. Invention.—Mr. Edison, in a recent interview, draws this sharp distinction between a discoverer and an inventor: "I never try to discover anything—because I am an inventor. There is a big difference between a discovery and an invention. Discovery is an accident and an invention is a creation. Mr. Bell discovered the telephone; he did not invent it. I invented the talking part."

Electricity in the French Navy.—Great interest is taken in naval circles in France in the possibilities of the application of electricity to naval uses. The government has taken the matter up, and proposes to institute a series of lectures for the benefit of naval officers on the theory and use of electricity. These lectures will be given by recognized experts and will extend over a period of four months. Particular attention will be paid to the various systems of electric lighting, which four working electricians from each naval port will carefully study under the direction of the government.

Berlin, Germany.—The underground telephone communications begun last year in Berlin have just been completed. The different sections of cast iron pipes, each containing 28 wires, branch off from the numerous exchanges, and lead to several connection boxes, where they are joined to the overhead lines. The total length of these tubes is about 34,000 yards, 10,000 yards of which are laid down as double set; 43,000 yards of cast-iron piping of ¾ inch to 1¼ inches diameter have been supplied for them, the biggest pipes being capable of holding 90 cables. Within one year 7,384 wires of about 3,700,000 yards in length have been drawn into the pipes, a large proportion of which are now in constant working.

Quotations on Electrical Stocks.—Messrs. F. Z. Maguire & Co., electrical securities, of 18 Wall street, this city, report the following quotations of Saturday, Nov. 15, from New York, Boston and Washington and Nov. 14 from Pittsburgh:

NEW YORK.

	Bid.		Bid.
W. U. Tel. Co.	76	Edison Gen. Elec. Co.	82½
American Tele. & Cable	83	Edison Gen. Co. Def'd	70
Cent'l & So. Amer.	155	Consol'd Elec. Lt. Co.	.....
Mexican	210	Edison Illn'g Co., N. Y.	60
Com. Cable Co.	101½	U. S. Elec. Lt. Co.	.....
Postal Tel. Cable	39	North Am. Phon'gph.	30

BOSTON.

	Bid.		Bid.
Thomson-Houston	39⅞	Ft. Wayne Co.	*11
" Pref'd	26¼	Am. Bell	210
" Series C.	11½	Erie	*47
" " D.	6	New England	51
" Int. Co.	.....	Mexican	.75
Thomson Welding Co.	180	Trop. American	.....
Thomson Eu. Welding	.....	Edison Phon'gph Doll.	2

*Ex-dividend.

WASHINGTON.

	Bid.		Bid.
Penna. Telephone	25	Eck. & Sold. Home Elec. Ry.	56
Ches. & Pot. Telephone	66	Georget'wn & Tenallyt'n.	50
Amer. Graphophone	11½		
U. S. Electric Lt. (Wash.)	140		

PITTSBURGH.

	Bid.
Westinghouse Electric Manufacturing Company	27½

Industrial and Trade Notes.

Medical Batteries.—Mr. George Wing, of East Portland, Ore., writes to the Jerome Kidder Manufacturing Company, of this city, as follows: "Ten years ago, I bought one of your Jerome Kidder batteries. Since then I have had two new zinc plates, and to-day, after ten years' use, I find the battery works as well as ever."

Smith & Vale, 112 Liberty street, this city, are furnishing large feed water pumps for the Newark (N. J.) Electric Light and Power Company's plant and one for the Rapid Transit Street Railroad Company, of Newark. Mr. Moore, the manager of the company, says that, notwithstanding a recent enlargement of the factory, the company has orders that tax the fullest capacity of the works.

Street Railway Belts.—On Aug. 20 last, Chas. A. Schieren & Co., 45-51 Ferry street, this city, furnished the Metropolitan Street Railway Company, of Toronto, Ont., with 48 feet of 12-inch and 85 feet of 28-inch double perforated belt. Mr. Chas. D. Warren, president of the company, speaks in very satisfactory terms of the performance of these belts. He says that they seem to meet all requirements.

J. D. Dillingham Co., New England agents for the Variety Iron Works of Cleveland, O., are meeting with great success in the sale of the "Butman patent shaking grate bar," which shakes from the ashpit door, the lever being always in place. After shaking the lever locks the bars in position and thus avoids any liability of burning out the sections. This device does not in any way interfere with the drawing of ashes.

Mr. Albert Bryan, 711 W. Third street, Seattle, Wash., has purchased the stock of electric bells, annunciators, burglar alarms and other house goods of the Northwest Electric Supply and Construction Company of that city. Mr. Bryan has been connected with the above company for some time, and, knowing the wants of the trade, will endeavor to carry such a stock as will enable him to meet the requirements of his customers.

The Hunt Engineering Company, of Brooklyn, N. Y., general contractor for electrical construction and electric light, power and railway plants, is very busy installing a number of large electric light plants in New York and other States. Mr. Alexander Henderson, well known in this vicinity, and formerly superintendent of construction for the Brush Electric Company through the South, has become foreman of construction.

The Electrical Supply Company, 171 Randolph street, Chicago, reports large sales and increasing demands for its celebrated "Shield" brand, moisture-proof line wire. This company has recently issued an attractive circular calling attention to the Shield brand, and publishing a number of letters from prominent electricians, warmly endorsing this wire. During the past two years the sale of Shield brand wire is said to have steadily increased, and it is reported in many instances other inferior wires have been replaced with Shield brand in entire plants.

The Tropical American Telephone Company reports that besides its regular American Bell Telephone Company's set of which it has just received a large consignment it is now offering a new Tropical American Telephone Company export set, the magneto having platinum points, and all latest improvements. The Tropical Company is making the "Williams" switchboard in a new form after the style of the multiple switchboard, and has it in all sizes, and is now exchanging these for old style boards or old style magneto-bells on very reasonable terms. The new export set is guaranteed to be first class in every particular.

J. Elliott Shaw & Co., the well known and reliable firm, have just moved into their new store and factory, No. 632 Arch street, Philadelphia, where they have increased accommodations for filling the orders that are made upon them for their Norway iron-frame wood-box bell. Their exhibit is exceedingly meritorious, and they deserve the patronage they are having. Their illustrated bell circular, which they have just issued, contains a number of reductions in price, yet the high standard of their goods is retained. Their double armature heavy-stroke bell is also making rapid strides, and gives them much satisfaction.

Magnolia Metal.—The Magnolia Anti-Friction Metal Company of 74 Cortlandt street, this city, has received from the New York and Brooklyn Bridge an excellent testimonial regarding the value of magnolia metal. Mr. C. C. Martin, the chief engineer and superintendent of the Brooklyn Bridge plant, says that he has had the magnolia metal in use about six months on the crank pin of the 450 h. p. Wright engine, and also as packing rings on the piston rod of a locomotive. In both places, he says, it has given entire satisfaction, not causing the least trouble. This speaks very highly for the value of the magnolia anti-friction metal.

Kirwan Station Indicators.—Mr. J. H. Olhausen, general superintendent of the Central Railroad Company of New Jersey, writing under date of Jan. 8, 1890, to Dr. G. H. Kirwan, of Wilkesbarre, Pa., concerning the Kirwan station indicators, says: "I wish to state that the station indicators subject to test on our through trains between New York and Scranton, for the past two months, have proven eminently satisfactory. In the opinion of our men they have passed beyond the bounds of an experiment. With proper attention, I have no doubt, the instruments will continue to give satisfactory results. Our passengers were more than delighted with them."

Tempered Copper.—Mr. E. W. Davis, superintendent of the Pittsburgh Traction Company, Pittsburgh, Pa., writing to the Eureka Tempered Copper Company, of North East, Pa., says: "I have great pleasure in being able to testify to the excellent quality of your tempered copper. We have been using a guide shoe made of it on a 500 h. p. Corliss engine for the past six months; it looks as well to-day as when we put it on. We are also using your metal for connecting rod boxes on a 35 h. p. Ball engine making 300 revolutions per minute. We find it takes much less oil than any other metal we have used and runs much cooler. We intend equipping all our engines with your tempered copper."

W. R. Fleming & Co., of 174 Fulton street, selling agents for the foundry and machine department of Harrisburg, Pa., have just taken an order for the equipment of several large steamships belonging to the Trasatlantica Espanola Line, with their self-oiling Ideal engines for electric purposes. This steamship company ranks among the three largest in existence, and is the one to which belonged the "Vizcaya" which was recently wrecked by collision attended with such disastrous loss of life. The "Vizcaya" was to have been equipped at once by W. R. Fleming & Co. They also report the receipt of many large orders for engines and their steel return tubular boilers from electric light and street railroad companies.

The Empire City Electric Company, 15 Dey street, this city, is considered among the largest manufacturers and dealers in electric supplies for electric light, power and railway work. This company lately secured the adjoining building, 17 Dey street, and has made connection between the present store in the first floor, basement and sub-cellar, and will fit up the main floor for office and reception room, remove the present office to this new building and increase the sales department. The company is now occupying the larger part of its present building for manufacturing some of its main specialties, such as batteries, bells, push buttons and minor lines of goods. When the new department is completed they will have one of the finest stores in the city.

The Central Electric Company, of Chicago, is sending out a "masterpiece" in the way of a fac simile letter to which is attached a small piece of Okonite wire held in position by a piece of red ribbon and an appropriate seal. The letter reads as follows: "This piece of Okonite wire was placed in our Lumber Exchange in this city five years ago, and has been used continuously ever since as part of the electric lighting circuit of the building. The wire was originally stapled to the fire-proofing and plastered over, and, so far as we can see, is as good as ever." This letter is signed by S.

G. Cook & Co., lumber manufacturers and merchants, of Minneapolis, Minn. The piece of Okonite in question is certainly well preserved, and the Central Electric Company, which is the general western agent for Okonite wire, is doing its customers a favor by this novel method of distributing samples for their inspection.

Receiver's Sale.—Albert C. Corre, receiver of the Novelty Electric Supply Manufacturing Company, has sent out the following notice of sale: "Pursuant to the command of the Superior Court of Cincinnati, to me directed, in case No. 45,000, upon the docket of said court, wherein Edward B. Tozier is plaintiff and the Novelty Electric Supply Manufacturing Company is defendant, I will offer for sale at public auction at 11 o'clock A. M., Monday, Nov. 17, 1890, on the premises, No. 264 West Fourth street, in the city of Cincinnati, Ohio, as an entirety, the manufacturing plant as a going concern, the lease of the premises and all the assets of the Novelty Electric Supply Manufacturing Company, of Cincinnati, reserving, however, all book accounts and bills receivable, and certain goods, chattels and machinery upon which liens are claimed, the latter to be sold immediately after sale of plant, subject to said liens.

Stanley & Hall, 32-34 Frankfort street, this city, manufacturers of electric bells, have been increasing their facilities lately, and have not forgotten to attend to the sales department. As a result, they are putting out thousands of bells every month. Their new improved solid armature rod and hammer, used only on their bells, has been a great improvement and is appreciated by buyers in that line. As they say in their circular: "The bell is not a phonograph, but it speaks for itself." The increase of their business has been so great that they have found it necessary to still further increase their floor space, and last week secured the main floor for offices, sales and shipping department. They are sending out advance circulars, as their new catalogue is now "in press." We find illustrated in it new improvements in excellent household and office specialties, and on their circular they illustrate their new needle annunciator and burglar alarm, also a new improved pivot armature skeleton bell, as well as other attractive goods.

The Jacobs Feed Water Heater.—Chas. Jacobs & Co. have opened offices at 65 Oliver street, Boston, and will at once put on the market the Jacobs water tube feed water heater and purifier. The essential qualities claimed for it are simplicity of construction, low cost and great efficiency. It is constructed of a cast iron shell or body, with seamless drawn brass tubes expanded into tube plates at top and bottom, with water chamber in the base, having a partition through the middle, which causes the feed water upon entering the heater to pass upward through the tubes on one side of the partition, then downward through the tubes on the other side to outlet. The tubes being surmounted by a cap forming a chamber at the top, and being fastened rigidly only to the lower tube plate, free play is given for expansion, thereby preventing rupture and leakage of joints. This company also owns Lowden patent grease, oil and grit extractor, for separating and automatically discharging grease, oil and grit from exhaust steam. This is said to be the only extractor having automatic discharge and removable plates.

The Thomson Electric Welding Company, of Boston, has perfected a new type of welding apparatus adapted to general miscellaneous work, which will be of value to small manufacturers who have not sufficient work to require the larger welding plants which this company is now placing in different parts of the country. These new machines are fitted with interchangeable clamps, so that various sections and sizes of metal can be welded without difficulty on the same machine. The new machine is novel in construction, and yet so simple in its conception that it will require little or no care or repairs on the part of any manufacturer using it. Such a machine will be of great value to machine shops, repair shops, railway car shops, the smaller carriage and wagon works, ship yards, and, in fact, wherever welding of a greater variety than quantity is now done by the old forge methods. These machines are being built of three different sizes, welding various sections from five square inches to small rods of iron or steel. Such a machine can be placed wherever it may be convenient in any factory, and available at a moment's notice for any welding that may be necessary.

The Economy Waste Oil Filter Company, 322 Pearl street, New York, has testimonials from the leading electric light power and railroad companies as well as from prominent mill owners in this country, and has compiled a part of the best references and testimonials in a very neat circular, which will be sent to any one on request. The "Economy" filters are said to effect a great saving in oil. Lubricating oils collected in drip pans, after passing through machinery, can be purified and rendered fit for use again; it does not matter whether the oil contains water, grit or any sediment likely to be collected in refuse oil. James A. Hearn & Son, the drygoods men of Fourteenth street, this city, have a large electric light plant. They had accumulated a large amount of waste oil, and, after hearing of the "Economy" waste oil filter at 322 Pearl street, called and purchased one on trial. They were so well pleased with its operations that in two days after its purchase they sent a check for it. Hollingsworth & Vole, of East Walpole, Mass., purchased one of these filters in November, 1889, and having found the first one a success bought the second one in July, 1890. The company has a number of such testimonials that it will be pleased to send to any inquirers.

New Factory.—When Chadbourne, Hazelton & Co. took the agency for the United States for the Wenstrom Consolidated Dynamo and Motor Company, last June, it was the intention of that company to equip their old factory at Locust Point with new machinery. They determined, however, later to build a new factory and purchased 100 acres of ground and commenced operations. The new factory has been somewhat delayed owing to the extremely rainy season, and there is such a demand for Wenstrom apparatus that they are entirely unable with their old facilities to fill their orders. At a recent meeting of the directors the situation was discussed, and in order to hasten matters the Wenstrom Company has rented a larger factory in Baltimore already equipped with boilers, engines and shafting. The new factory is 60 feet front, 260 feet deep, is three stories high, and will be in working order by the last of this month. The company expects to be able to turn out enough machines here by working day and night to fill the most pressing orders, and in the meantime will push to completion the large new factory at Calverton, which will be ready for operation by the early spring to meet the spring trade and the demand for street railway apparatus, to which this new factory will be almost entirely devoted. This will give the Wenstrom Company excellent facilities.

Locke's Damper Regulator.—As the consumption of coal is a great factor in the economical running of an electric light station, any device that will reduce the amount used and thereby result in a saving in the expenditure for fuel is eagerly sought after and if found to be useful will be very extensively adopted. The Locke gauge testing damper regulator manufactured by Locke Brothers, of Salem, Mass., seems to be of this character. The advantages claimed for it are: First, it handles the heaviest dampers, or any number of them, and changes their position to correct variations in steam pressure even of one-sixteenth of a pound; second, this great accuracy in regulation of the fires is the secret of the great saving in fuel which is claimed to be effected by this regulator. The United States government, after thorough trial and investigation, has adopted this regulator for the capitol at Washington, the navy yards, Boston post office, the United States sub-treasury building, etc. The government tests show very high economy in fuel, combined with great accuracy in controlling the fires and steam pressure. Testimonials of the highest character have been received from the United States Electric Light Company, Washington, D. C., the Boston Electric Light Company, Institute of Technology, Boston, and various others. This regulator is now on exhibition at the Mechanics' Fair, Boston.

Interesting Exhibit at the American Institute Fair.—One of the greatest attractions at the Fair this year is W. H. Gordon & Co.'s exhibit of the Automatic Clock Company's specialties. The sign at the exhibit reads: "The automatic clock will do anything that can be accomplished by releasing a spring or dropping a weight. You hang the chain on the clock, we do the rest." The exhibit warrants the above statement. It shows the clock attached to the switch of an arc light circuit, and also shows the clock and cut-out in a handsome case as used for extinguishing incandescent lights. The clock is also shown attached to the front and back drafts of a heater for opening them at an early hour in the morning if so desired. The clock is also attached to a feed box and water tank so that a horse may be automatically fed at any time desired. This company is shipping clocks to all parts of the country for a variety of purposes. One was recently shipped to Atlanta, Ga., to unlock a door. In Quincy, Ill., a certain firm uses one of these clocks to open two heavy iron doors on its japanning ovens, and a Lockport dry goods firm uses one of them to turn off a gas meter. Orders for the clock and cut-out used largely for extinguishing lights in merchants' show windows are coming in quite freely. W. H. Gordon & Co., 115 Broadway, this city, who are making the exhibit of this apparatus at the Fair, are the general agents for New York and vicinity.

Queen & Co.'s Portable Testing Sets.—Prof. T. C. Mendenhall, superintendent of the United States Coast and Geodetic Survey, says: "The set of resistance coils furnished by you some time since has been used with great satisfaction. It possesses many advantages in the way of compactness and convenience of arrangement." Secretary H. J. Davies, of the Brooklyn Street Railroad Company, writes: "We are very much pleased with the portable testing set you sold us. We are using it constantly, and it is proving satisfactory." Assistant-Engineer Fleming, of the Edison General Electrical Company, writes: "I would say that the portable testing set I bought of you recently has given satisfaction, and, for an instrument of its class, surpasses anything I have ever seen for accuracy and reliability. I would heartily recommend it to electricians." Superintendent H. A. Wagner, of the Missouri Electric Light and Power Company, says: "We are very much pleased with your new portable testing set, which we have been using about two months, and have no hesitation in saying that it is the best instrument for the price that we have seen. We have had it compared with a standard Elliot bridge, and the readings when reduced to B. A. ohms agreed with the former within one-tenth of one per cent. throughout the range tested." The Schaefer Electric Manufacturing Company writes: "So far as we have been able to test the set has proven all we could wish for, and well adapted for our purposes." Lieutenant McLean, of the Newport Naval Torpedo Station, says: "The arrangement of the bridge arms, coils and keys in the portable testing set No. 126 is very convenient and satisfactory." Queen & Co. report that up to date the orders for these sets have come so rapidly that it has been impossible to turn out the instruments fast enough. They have employed additional force, however, and hope soon to be able to carry a supply equal to the demand.

Alexander, Barney & Chapin consummated an arrangement last week, which is of interest to all manufacturers of electrical apparatus and appliances. For some time past they have made "Alexite" in small quantities, not having found sufficient manufacturing facilities to fill the numerous orders they had received. Peculiarly constructed machinery was necessary, large hydraulic presses to press the material, etc., to build which would have taken considerable time. It is said that the only manufacturer in New York using machinery adapted for that purpose was the Fibrone Manufacturing Company, of 300 to 302 Monroe street, and Alexander, Barney & Chapin have just now arranged with them not only for the manufacture of "Alexite," but for all goods made by them for electrical purposes, the Fibrone Manufacturing Company in turn agreeing not to make goods of that nature in any of the four materials which are named below for any parties in the United States or Canada outside of Alexander, Barney & Chapin. The materials to be manufactured are as follows: (1) *Plasticon*, most generally used now for switch handles, etc., which can be furnished in all colors and made to imitate wood, marble, etc. Besides being perfectly water-proof, this material will withstand a high degree of heat. Such a material is largely in demand for a great many purposes on account of its beautiful appearance, and will doubtless find very extended use. Brass parts can be imbedded in plasticon, an advantage which will be readily appreciated. (2) *Fibrone*, a material similar in appearance to plasticon but standing a much higher degree of heat. It can be tapped and drilled, worked on a lathe, and can be finished to a high polish, the same as wood can be. As a substitute for hard rubber it has many advantages. Its low cost is one important item, besides the facility with which it can be handled. The fact also that it can be made in colors is calculated to give it a very widespread use. Fibrone can also be worked in sheets of any thickness, and is, therefore, well adapted for the insulating material used in sockets, as it is absolutely water-proof. (3) *Alexite* is claimed to be absolutely fire, water and acid proof. It can be molded in any shape and given any color. While the manufacture of safety appliances for electric lighting has been improved very much during the past few years, there has been but one prominent fire-proof material for use in cut-outs, switches, etc.—porcelain. With the new material brass parts can be firmly imbedded in the mold, thus adding strength to beauty. (4) *Herculite* is also claimed to be a fire, water and acid proof material, having something of the nature of fibrone, and can be used for many special electric purposes, particularly where immense tensile strength is required, or where the quantity to be manufactured will not justify the making of a mold. This material can be made into sheets as large as 10 feet square, and having a very light weight it is suitable for switchboards. It can be drilled and tapped as well as any wood, and can be made in any color. Sixteen new hydraulic presses are being added to those already contained in the Monroe building, and with the additional floor space taken, Alexander, Barney & Chapin hope to fill promptly all orders given them for goods in any of the above materials.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Proper Place for Dynamos.—In a private or isolated plant, is there any law, or rule, which will compel a person (hotel keeper for instance) to put a dynamo 50 feet from his building? If rules are complied with, ought it to affect the insurance rates?

E. M. S.

We know of no general law regarding the position in which isolated plants shall be placed. Insurance companies have, however, their own rules and notions as to such matters, and the question must be adjusted with their representative. If an insurance company doesn't care to insure a place except on given conditions, of course they cannot be compelled to do so.

Street Car Gearing and Carbon Trolley.—Will you please answer the following questions: (1) What is the ratio of gearing between motor shaft and axle on an ordinary electric street car? (2) Has worm gearing ever been tried for the purpose, and with what success? (3) Would there be any advantage in using a carbon trolley wheel?

R. W.

(1) The ratio varies somewhat in different systems, from 10 to 1 to 12 to 1. (2) Worm gearing has been tried, and with a special worm gives very fair results, although the efficiency is not as high as might be desired. (3) We do not see any special advantages to be obtained from using a carbon trolley wheel. The best way to look for them would be to try one.

Relation of Electromotive Force to Sparking Distance.—(1) What would be the electromotive force from the secondary of an induction coil giving a half-inch spark? (2) Would the electromotive force from a secondary coil giving an inch spark be just twice that giving a half-inch spark?

F. S. W.

(1) Experiments are considerably at variance regarding the exact electromotive force required to produce a spark of a given length. In a general way you might estimate the half-inch spark as corresponding to 25,000 to 30,000 volts. (2) The electromotive force required to produce a spark does not increase as rapidly as the distance. An inch spark could be obtained with decidedly less than twice the electromotive force that would give a half-inch spark.

Armature Resistance.—(1) Suppose I have a Gramme armature wound with 1,000 feet of a certain size wire, the resistance of which is 10 ohms; what would be the resistance of the armature, coupled up in the usual way? (2) What size wire should be used in making a Bell telephone receiver? (3) About what would the resistance of the bobbin be? (4) About how much wire is necessary?

F. B. W.

(1) The resistance from brush to brush of a complete armature is one-quarter the resistance of the wire wound upon it; that is to say, if there are 1,000 feet of wire on your armature, as it is wound you have two lengths of 500 feet in parallel. (2), (3) and (4) For details of amateur telephone making, we cannot do better than to recommend you to Hopkins' "Experimental Science," which can be had at this office, pages 575 and following.

Induction Coil for Gas Lighting.—(1) I wish to make an induction coil for multiple gas lighting, the particular work being to light the dome of a theatre, about 30 jets. What dimensions shall I make the coil, and how shall it be wound? We used an induction coil for the above purpose a few years ago which worked perfectly, but it was unfortunately stolen. Since then we have used frictional machines, which we have concluded to replace, as they do not work in wet weather. (2) Is a good telegraph key any better than a strap key for making and breaking a circuit?

MECHANIC.

(1) On general principles we would not advise you to try home-made induction coils, as the winding requires special precautions in the way of insulation. Better replace the coil you lost. (2) A telegraph key enables you to make and break a circuit more quickly than an ordinary strap switch, on account of its convenient mechanical construction. Otherwise it has no advantage that we know of.

Business Notice.

Battery Cut-out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Co., of 105 South Warren street, Syracuse, N. Y.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS

U. S. PATENTS ISSUED NOV. 11, 1890.

440,164. Telegraph Circuit; David Herbert Keeley, of Ottawa, Canada. Application filed Nov. 4, 1889. In a telegraphic system, a pole-changing transmitter, in combination with a rapidly and constantly acting current-reverser at the receiving station for either neutralizing or augmenting the impulses transmitted.

440,165. Multiplex Telegraphy; David Herbert Keeley, of Ottawa, Canada. Application filed Nov. 4, 1889. The multiplex telegraph, commutators at both ends of the line operating to present currents to line concurrently plus at one end and minus at the other, and the reverse, alternately, in combination with an arrangement of keys and transmitters, whereby when the keys are depressed the path to line for the currents of one polarity is interrupted, while the path for the currents of opposite polarity is established, and when the keys are upraised the reverse effect is produced.

440,175. Secondary Battery; Frederich Marx, of Berlin, Germany. Application filed April 18, 1890. A secondary or storage battery, consisting of a metal or metalline electrode and a carbon electrode, said electrode being placed in an aqueous solution of a salt of a metal and an equivalent quantity of an acid.

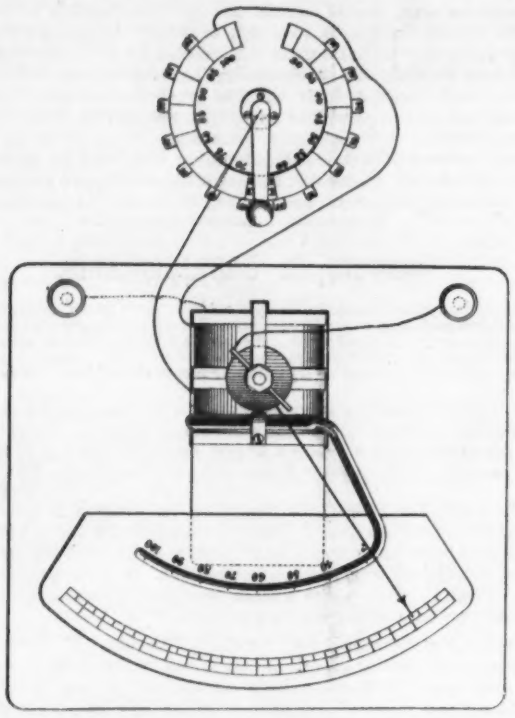
440,189. Electric Motor Truck and Gear; Edgar Peckham, of New York, N. Y. Application filed May 29, 1890. In an electromotor truck, the combination, with the truck axles and longitudinal supporting bars arranged inside the car wheels and journaled on the car axles, of an electromotor flexibly connected with the axle or axles of the truck, an armature shaft supported in bearings on the longitudinal bars, a pair of counter shafts also supported in bearings on said longitudinal bars, and gearing connecting said armature shaft and counter shafts with the driving axles.

440,199. Induced Current Telegraph; Abner M. Rosebrugh, of Toronto, Canada. Application filed Feb. 3, 1886. In an induced-current telegraph, the combination with the inductorium and circuit-closing key in the primary circuit thereof, a rheotome or its equivalent in said primary circuit, and a secondary circuit of the inductorium in the line and a shunt around said inductorium.

440,208. Station Indicator for Electric Railway; George N. Vanderhoef, of Bayonne, N. J., Assignor to the Invention Company, of New York, N. Y. Application filed Dec. 2, 1889. The combination of a number of indicator-tablets, a number of pointers, a connection for producing a relative movement between the indicator-tablets and the pointers common to all the said moving parts for operating them in unison, and electro-magnetic mechanism controlling the movement of the parts.

440,210. Electrode for Secondary Batteries; Edward B. Weed, of Detroit, Mich., Assignor to John E. Wiles, of same place. Application filed Feb. 8, 1890. An electrode for secondary batteries, consisting of a metallic supporting plate having outwardly-projecting receptacles for the active material or materials to become active, said receptacles being formed so as to wholly inclose the masses of active material and being indented or flattened.

440,213. Electric Switch; Malone Wheeless, of Nashville, Tenn., Assignor by direct and mesne assignments to the Wheeless Electric Railway Company, of Alexandria, Va. Application filed Sept. 24, 1889. An electric circuit separated at intervals and having at each side of the points of separation sockets pointing in opposite directions, in combination with magnets placed at such points of separation, the armatures of the magnets being bifurcated, and the forks being on opposite sides of the main circuit and having screws fitting the sockets.



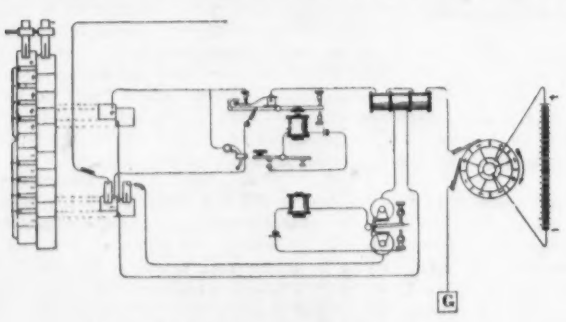
No. 440,290.—TEMPERATURE REGULATOR FOR ELECTRICAL MEASURING INSTRUMENTS.

440,216. Secondary Battery Plate; Albert E. Woolf, of New York, N. Y. Application filed Feb. 10, 1890. An electrode comprising essentially a plurality of supports for active material, the supports being conductors of electricity and a layer of mechanically-applied active material between and in contact with the surfaces of adjoining supports, and continuous open passages for the liquid of the cell made through the supports and through the active material.

440,224. Distribution of Electrical Energy; Sebastian Ziani de Ferranti, of Hampstead, England. Application filed Feb. 19, 1890. The combination of a dynamo-electric machine, concentric conductors, insulated from one another, leading therefrom, a converter inclosed within the outer conductor and another conductor passing through a continuation of the outer conductor, conveying current induced in the secondary of the converter to branch main conductors, and through them to second converters, also inclosed in the outer conductor.

440,241. Electric Actuating Mechanism for Clocks; Herman Theodore Schlegel, of Akron, Ohio, Assignor by direct and mesne assignments of three-fourths to Albert A. Schlegel and Michael J. Gelbro, both of same place. Application filed Sept. 6, 1889. In an actuating mechanism for clocks, the combination, with an electromagnet and its pole and an electrical circuit, of a rocking lever having a vibratory rock-arm extending rigidly therefrom and having intermittent contact with the pole, a contact point mounted on the rocking lever, and an electrical terminal connected with the point and to one of the poles of the magnet, a contact plate, and means for oscillating the same, said plate being connected with the opposite terminal of the electric wire and adapted for contact with the point of the arm.

440,289. Dead-Beat Mechanism for Electrical Measuring-Instruments; Edward Weston, of Newark, N. J. Application filed May 12, 1890. The invention consists, first, in the method of retarding the movement of an electrically actuated body by first establishing the actuating-current, then diminishing a previously interposed frictional resistance and allowing the body under the influence of the current and opposed by the resistance to move slowly to the indicated point, and then removing the resistance; and second, in an apparatus whereby said method may be carried into effect (said apparatus and method actually interdependent and related) and containing, essentially, a body of inductive material supported and vibrating in a field of force, and a means of opposing a frictional resistance to the motion of said body.



No. 440,165.—MULTIPLEX TELEGRAPHY.

440,290. Temperature Regulator for Electrical Measuring Instruments; Edward Weston, of Newark, N. J. Application filed June 25, 1890. In an electrical measuring instrument, a means of indicating changes in temperature occurring in the instrument circuit, and connected in said circuit a resistance and a means of varying the same comformably to the indications of said heat indicating apparatus, whereby the resistance of the whole circuit may be maintained constant despite temperature variations.

440,291. Index Controlling Device for Electrical Measuring Instruments; Edward Weston, of Newark, N. J. Application filed June 25, 1890. In an electrical measuring instrument, a pivoted body, a means of indicating the extent of rotary movement of said body, and a second body moving about a centre in line with the centre or rotation of said first pivoted body, one of said bodies being provided with a laterally-projecting stop or pin and the other having a recess in which said stop enters and whereby the path of movement of said stop is limited

440,303. Electric Switch; Arthur R. Bush, of Boston, Mass. Assignor to Paine & Francis, of same place. Application filed June 9, 1890. The combination, with a base provided with pole-pieces having contact-brushes, of a contact-arm loosely mounted on a spindle supported by the base and attached at one end to the contact-arm and at the other end to the spindle, lugs on said spindle, and a pin on said contact-arm extended between said lugs to be engaged and positively moved thereby when the needle is turned to move the contact-arm.

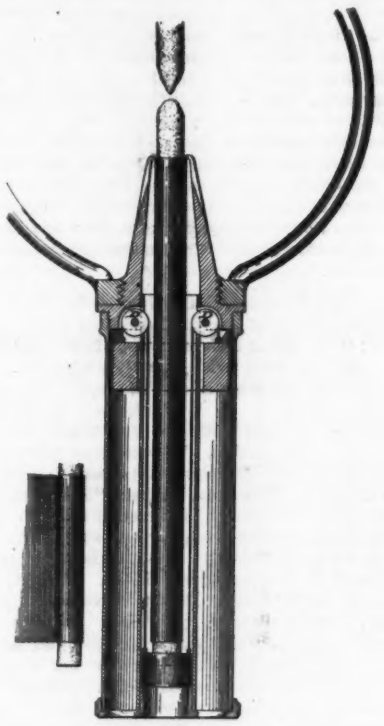
440,326. System of Electrical Distribution; Walter S. Richards, of Natick, Assignor of one-half to George B. James, of Boston, Mass. Application filed May 2, 1890. In a system of electrical distribution, a dynamo or equivalent generator, two circuits and a current-director, one of which circuits includes the coils of the field-magnets of the dynamo and the other translating devices.

440,361. Combined Lightning Arrester and Cut-out; John A. McManman, of Milwaukee, Wis. Application filed Feb. 7, 1890. In a lightning-arrester and strong-current protector for electric systems, a continuously raised elongated hollow ground-bar of inverted-U form in cross-section interposed between the line and office wires, with its longitudinal axis extending transversely of the terminals of said wires, the terminals of said wires being adjacent to opposite sides of said bar.

440,362. Electric Railway; James K. P. Nourse, of Boston, Mass., Assignor to himself, Luther Daniels, of same place, and John A. Fogg, of South Weymouth, Mass. Application filed March 18, 1890. This system embraces a vehicle provided with an electric motor and storage batteries, a conductor of electricity leading from a central station or generator and at intervals passing in proximity to the line of travel of the said vehicle, although not necessarily or ordinarily following that line of travel, and a connection adapted to form a path for the current from the generator to the storage-battery on the vehicle when connection is established between them at one of the points previously mentioned where the electrical conductor meets the line of travel of the vehicle.

440,384. Adjustable Resistance for Electrical Circuits; Charles Wirt, of Orange, N. J. Application filed Nov. 26, 1888. This invention employs two concentric cylinders or drums, one carrying resistance-coils, the other a contact device bearing thereon, such drums being movable relative to each other, whereby more or less of said coils are included in the circuit whose resistance is too varied. The inner drum is preferably stationary and the outer one movable.

440,420. Galvanic Battery; William Cohlman, of Philadelphia, Pa. Application filed Jan. 20, 1890. The combination in a multiple-cell battery of a frame and a series of battery-cells fitting closely in said frame, and each consisting of a closed box partitioned to form compartments for the battery elements, and having the conductors for said elements carried through the front of the box to binding posts on the outside of the same.



No. 440,604.—ARC LAMP.

440,424. Dynamo Electric Machine; Walter K. Freeman, of Brooklyn, N. Y., Assignor to William S. Hadaway, Jr., Trustee, of Boston, Mass. Application filed Sept. 20, 1890. The combination of a core, a coil, a removable head surrounding the pole of the core for holding the coil upon the core, and bolts by which the head is held in place passed through the head on the inside of the coil.

440,425. Current-Collector for Dynamo Electric Machine; Walter K. Freeman, of Brooklyn, N. Y., Assignor to William S. Hadaway, Jr., Trustee, of Boston, Mass. Application filed Sept. 20, 1890. In a collector for dynamos, the combination, with a metallic rim or hub having a peripheral projecting flange or flanges, of a metallic outer rim provided with inwardly-projecting flanges and insulating material interposed between said rim and hub and secured to the flanges thereof.

440,431. Electric Meter; Etienne Marés, of Paris, France. Application filed Feb. 26, 1890. In an electric meter, the combination, with the balancing lever mounted to oscillate and an electro magnetic device for actuating said lever, of a carriage on the lever, mechanism for reciprocating the carriage, and a registering device in the path of the carriage and separate and independent of the carriage and lever.

440,441. Electric Clock; Frank Schwartz, of Halifax, Can. Application filed Oct. 22, 1889. This invention consists in the provision of electro-magnets of correct proportions, supported on each side of a pendulum to which laterally-projecting armatures are affixed near its point of vibratory suspension, and that are carried by the movement of the pendulum within the field of force of the successively energized magnets, and are attracted by them, said magnets being adapted to be alternately thrown into circuit with a local by the vibrations of the pendulum, and thus cause the pendulum to complete its predetermined arc of vibration at each terminal thereof. This movement is directly communicated through pallet-limbs to an escapement wheel that is in gear with a train of speed-reducing wheels which it actuates, so that attached hands will indicate correct time on the usual face or dial of the clock.

440,502. Electric Railway Switch and Signal Mechanism; Joseph Ramsey, Jr., and Frederick C. Weir, of Cincinnati, Ohio. Application filed March 21, 1889. The combination, with a railway switch and the switch bar, of an electric motor near the switch, driving mechanism connecting said motor with the switch bar, an electric circuit, and an automatic circuit-breaker operated by said driving mechanism to break and reconnect the circuit.

440,503. Electric Switch and Signal Mechanism; Joseph Ramsey, Jr., and Frederick C. Weir, of Cincinnati, Ohio. Application filed March 21, 1889. The combination, with a railway signal, of an electric motor provided with mechanism for operating the signal in one direction only, an electric generator in circuit with said motor, an automatic circuit-breaker for cutting out the motor after it has actuated the signal, and mechanism for cutting in a magnet circuit for holding the signal.

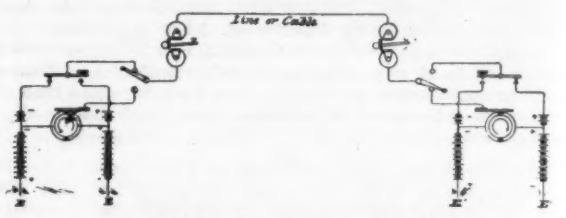
440,505. Electrolyte for Secondary Batteries; Bernard Renault and Maurice Desvernay, of Paris, France. Application filed Jan. 11, 1890. A depolarizing gelatinous silica for electric batteries, consisting of a mixture of water, bichromate of soda, and silicate of soda.

440,508. Electric Train Signal; Fitzwilliam Sargent, of Aurora, Ill. Application filed May 6, 1890. This invention comprises a whistle located on the engine suitably connected to a reservoir of air or steam, the operating-valves thereof being controlled by a suitable electromagnet, the arrangement of the parts being such that the whistle is blown whenever an electric current passes through the circuit, ceasing to sound upon the cessation of such current, the parts being also preferably so arranged with only the magneto-generator which is used for the purpose of sending the signal in the electromagnetic circuit at that time and out of such circuit at all other times.

440,534. Method of and Apparatus for Making Metallic Wheels by Electricity; William P. Bettendorf and Joseph W. Bettendorf, of Davenport, Ia. Application filed May 26, 1890. The invention consists in introducing the spoke into an opening in the hub, heating the two parts while in this relation by means of an electric current passed through them, and then subjecting the spoke while thus heated to pressure in an endwise direction. The invention also involves the application of the spoke to the rim in like manner.

440,557. Dynamo Electric Machine; Walter K. Freeman, of Brooklyn, N. Y., Assignor to William S. Hadaway, Jr., Trustee, of Boston, Mass. Application filed Sept. 20, 1890. In a dynamo electric machine, the combination, with the keeper ring having the cores of the field-of-force magnets thereon, of side sections having heavy corner-pieces and bolted against the sides of the keeper-ring, and also having the journal boxes for the commutation-shaft at the top.

440,563. Combined System of Fire Alarm and Police Patrol Telephone and Telegraph; George C. Hale and Albert Barrett, of Kansas City, Mo. Application filed March 28, 1890. In a system of fire and police alarm, the combination of a closed circuit to fire headquarters and provided with a signal-receiving device, an independent closed circuit to police headquarters, also having a signal-receiving device, an outlying



No. 440,164.—TELEGRAPH CIRCUIT.

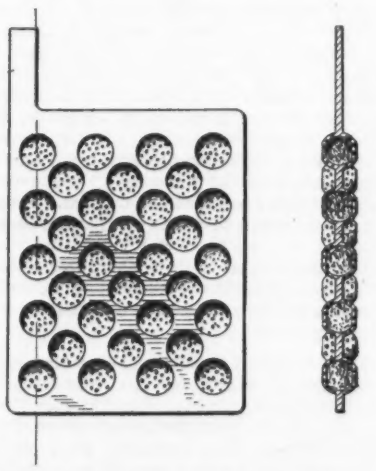
street station having a telephone apparatus, which is included in the normally-open ground line, and adapted to be interposed into either of said circuits at will, a pair of magnets at said street station for each circuit and which are normally cut out of their circuit, connections between the armatures of the two pairs of magnets and the single telephone apparatus at said outlying station, and the independent switches included in the closed circuits and arranged to operate the magnets to interpose the same and the telephone apparatus at the outlying station in one of the closed circuits, and at the same time to break the closed circuit momentarily and operate the signal device at headquarters.

440,584. Shipper for Trolleys; Herbert H. Brooks, of Cambridge, Assignor of one-half to Arthur F. Bardwell, of Boston, Mass. Application filed May 14, 1890. A shipper device for trolleys, consisting of two diverging pivotal arms, one in either side of the said trolley and extending outwardly from either face thereof, said arms projecting normally when the trolley is in contact with the wire below the said trolley and below any portions the overhead construction adjacent thereto.

440,590. Electrical Governors; Franklin D. Hardy, of Chicago, Ill., Assignor of part to Crews & Owen and Edwin J. Blood, all of same place. Application filed Feb. 1, 1890. The combination, with an electric motor, of a governor actuated by centrifugal force, a sleeve on the motor shaft, a bell crank lever connected thereto, and a pitman connecting the lever to the brush-holder of a dynamo.

440,595. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa., Assignor by mesne assignments to the Thomson-Houston Electric Company, of Boston, Mass. Application filed Sept. 23, 1886. Divided and this application filed May 29, 1889. The combination of a railway-track, a line of posts or poles along said railway-track, a supply-conductor and a working-conductor suspended by said posts and connected in parallel, a traveling car running upon the track, a collector moving with the car and making a traveling contact with the working-conductor, a circuit carried by the car connecting the collector with the railway track (which track acts as the return conductor), and a translating device carried by the car and receiving current from said circuit.

440,596. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa., Assignor to the Electric Car Company of America, of same place. Application filed March 24, 1887. Divided and this application filed July 28, 1890. In two crossing electric railways, the main conductors of each railway severed at the point of crossing the other.



No. 440,210.—ELECTRODE FOR SECONDARY BATTERIES.

440,597. Contact Device for Electric Cars; Rudolph M. Hunter, of Philadelphia, Pa., Assignor to the Electric Car Company of America, of same place. Application filed Jan. 26, 1887. Divided and this application filed May 15, 1890. Again divided and this application filed Aug. 11, 1890. In an electric railway, the combination of a conductor extending along the railway, a traveling vehicle, a frame jointed at one end to the vehicle and having its other end free, and a current-collecting device carried upon the free end of the frame and movable about a vertical axis.

440,604. Arc Lamp; Samuel E. Nutting, of Chicago, Ill., Assignor to the Nutting Electric Manufacturing Company, of same place. Application filed March 10, 1890. In an arc lamp the combination of an electrode, a covering for the same of a material that disintegrates under the heat of the arc at a temperature lower than is necessary to consume the electrode, with its edge next to the arc at a distance therefrom to cause it to be disintegrated with the same degree of rapidity as the electrode is consumed, and a holder bearing against the edge of the covering next to the arc and holding the electrode from advancing until the edge of the covering is consumed.

Copies of the specifications and drawings complete of any of the patents mentioned in this record—or of any other patents issued since 1886—can be had for 25 cents. Give the date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.

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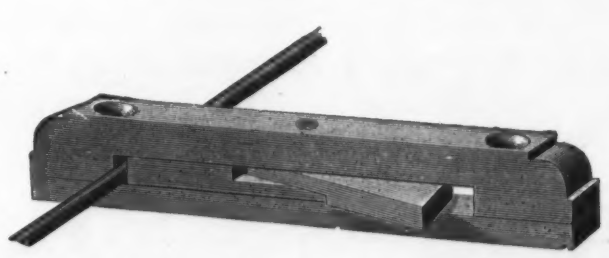

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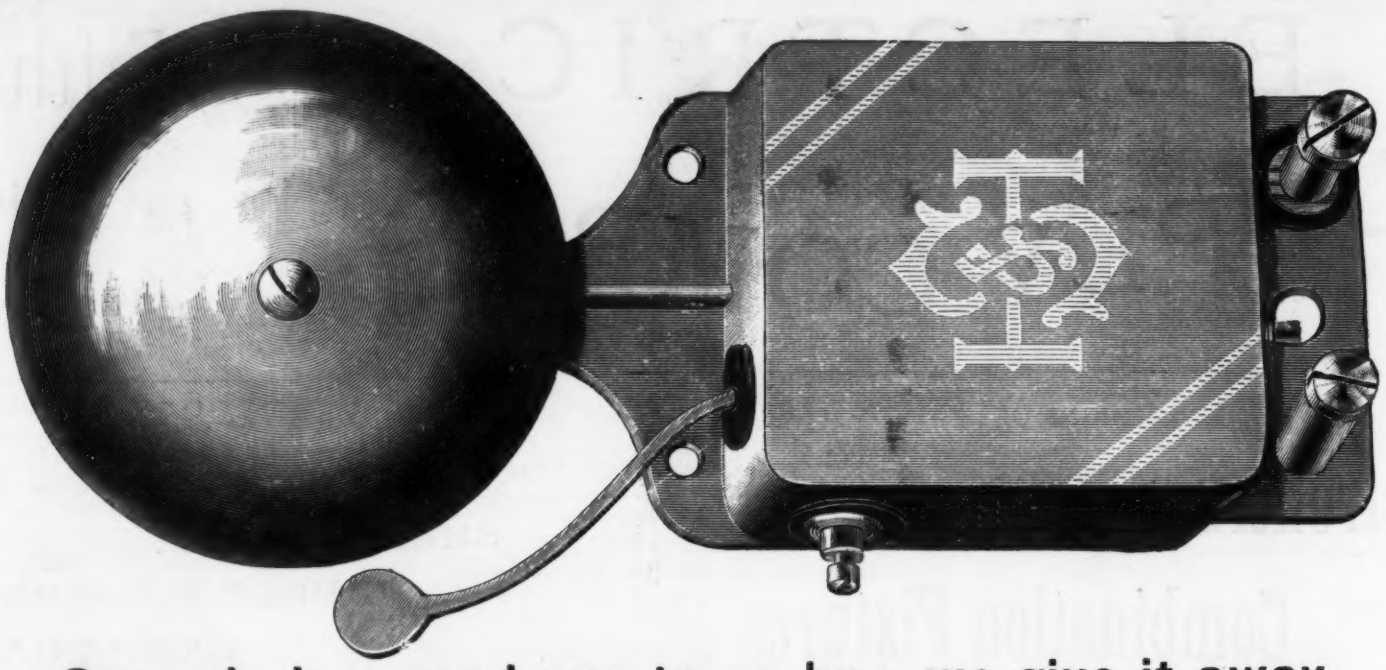

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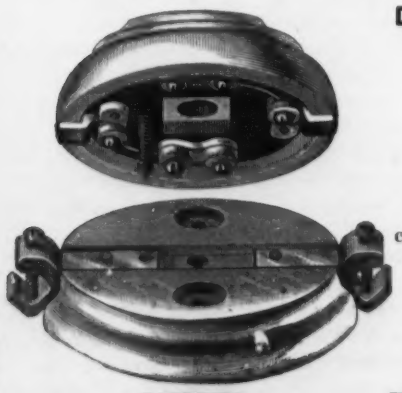

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